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KJ-8927 WAS $24.95

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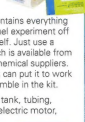

The kit includes Ethanol storage tank, tubing, purging valve, supporting base, electric motor, wiring with crocodile clips, fan blades, Ethanol solution mixing container and pH measuring strips.

$129.00
SAVE $70.00

- Recommended for ages 12+
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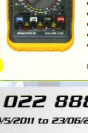

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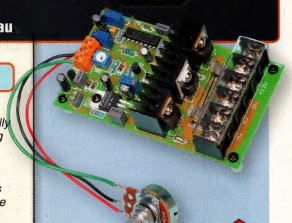

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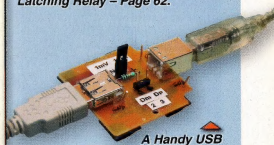

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Publisher's Letter

Let's forget about a carbon tax and concentrate on the environment instead

Since I wrote the Publisher's Letter entitled "Let's have no more of this carbon pollution nonsense" in the June 2009 issue of SILICON CHIP, the political climate seems to have changed dramatically – more than I could ever have expected in such a short time. Not only did the Copenhagen climate summit collapse in disarray but there has been a general shift in people's attitude to climate change.

While most people seem to feel that climate change is happening and that human activity is at least partly to blame, there is no consensus on what to do about it. One thing is certain: the science is no longer "settled", in spite of the increasingly shrill declamations by those who are certainly not disinterested. And it seems that the number of "climate change deniers" has greatly increased.

The Federal Government's move to introduce a "carbon tax" next year has not been favourably received and nor does there seem to be any remotely popular alternative strategy. And there is a growing realisation amongst the populace that action by Australia will have a significant cost and will have major employment ramifications. A tiny reduction in our greenhouse gas emissions when they are already virtually insignificant in the total world emissions means the whole process is futile, if not farcical.

All of which means that recent moves by the Greens political party to ramp up the use of renewable energy are worrying. They have a long-term aim of making all energy renewable and hang the consequences, whether it means much higher prices for electricity or lots of job losses – they simply don't care.

In an ideal world, we should not have coal-fired power stations and I have written along these lines in Publisher's Letters in years past. My opposition to coal-fired power stations comes not from any concern about carbon dioxide – it is not a pollutant – but with the long-term damage to the landscape and water resources, both by open-cut and underground mining.

However, there does not seem to be any support by the current Federal Labor government for any reduction in coal mining, whether for use in power stations or for export; quite the contrary in fact. With one eye on the union membership of mines and the power industry and with the other eye on ever-growing royalties and taxes, there is no stomach at all for any reduction; they want more coal mining, not less. And they want other forms of coal exploitation as well, in the form of coal-seam gas projects.

Which also means that the current Federal Government's infatuation with a carbon tax to combat climate change is hypocritical to say the least. We can state that the Greens are consistent in this respect – they want to stop all coal mining. But they pretty much want to stop everything, don't they?

I am coming around to the view that governments should do nothing to combat climate change, since its causes are extremely complex and still not understood. In any case, all previous moves to "do something" by the present government have been seriously misguided, and that is putting it mildly.

Nor do I think that there is any need to panic. Even if we are experiencing global warming, as opposed to the much more vague term, "climate change", there is not likely to be any "tipping point" in the foreseeable future. Secondly, as Climate Change Commissioner Tim Flannery has admitted, any action that we do take is likely to take centuries before it has any measurable effect.

Instead, governments should act to promote economic activity while still doing all they can to protect our environment. The two aims are not mutually exclusive. A carbon tax will not have any beneficial effects.

Leo Simpson

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Coping with wide mains voltage variations

In the same issue as your helpful auto-transformer voltage bucking project (Mains Moderator, SILICON CHIP, March 2011) you comment on a related letter on page 104 by suggesting that while ferro-resonant AC voltage regulators are best, you are unsure whether they are still available.

Where the mains voltage is fairly constant but is the wrong value, your auto-transformer project naturally is the best economic solution and provided its ratings are not exceeded nothing will be more reliable. However, for someone with very variable voltage, say a household a few miles down the long country line you instance, a better solution than a ferro-resonant transformer might be an on-line or no-break "sinewave" UPS.

From time to time they can be bought secondhand on eBay for relatively modest sums, even up to a kVA or two. They are quiet, fairly efficient and apart from the gel cells, tend to be quite reliable. However, as long as no hold-up is demanded of them, no or only a very modest battery will be needed.

Nevertheless you will be pleased to know the ferro-resonant regulators are indeed still manufactured. In addition to Asian sources, the firm that was perhaps the most well-known of the traditional suppliers, Sola of the USA, lists models which are more or less unchanged from 20 years ago, right down to the catalog numbers.

You are right that they are pretty expensive new. They are also unavoidably noisy due to the high degree of saturation in the core and for the same reason are pretty lossy and run hot; full load efficiency would not exceed 85% and no load losses are around 8-10% of nameplate rating, which is a significant factor these days if they are run for extended periods.

Ratings tended be quite modest. For example whereas units of say 100-500VA were plentiful, a 1kVA unit was large, heavy and in my experience not too common.

At our home on a rural NZ road fed by the proverbial "piece of wet string", the nominal 230V mains is set high at around 245V on light load and regularly varies between about 210V and 250V. On occasion it gets as low as 190V. I successfully deploy both small vintage "ferros" and a Variac servo regulator to supply my vintage test gear and receivers. We just accept the short household lamp (globe) life though.

John Reid,
Tauranga, NZ.

Film-to-DVD conversion tricks

I'm sorry that the article on transferring movies to DVD (April 2011) was not around five years ago when I needed it. I struggled with all sorts of electronic magic for timing but I suggest that your readers use DVD Infinity at North Sydney for easy and excellent results on mini-cassettes or DVDs.

But this is the only the start of the problems. Older film has a nasty way of twisting, distorting and shrinking. If you look along it, it appears curved

Maximite computer is a big hit

From the relative isolation of where I sit, the Maximite looks to be a big hit.

First, although I owned every issue of ETI & EA from my arrival in Australia (in late December 1977) until the mid 1990s, I have never until now been able to buy SILICON CHIP more than rarely. This arose when my life took me well away from electronics (part career, part disability). This year, the Maximite changed all that and I have bought three consecutive issues.

Second, I decided to buy the kit from Altronics. What a friendly and helpful company. Because of demand forecast, I probably will not get my kit before June, although they are working as fast as they can. So I am hoping that Geoff Graham and readers will keep on developing for the Maximite.

I must admit to a little surprise. In the old days, EA & ETI were meticulous about mentioning errors and updates in the magazine. I have found online that the originally printed schematic had an error. Although this was mentioned and corrected online, I think you may be a little over-dependent on the internet.

On the plus side, I see great potential for this kit, even given my woeful lack of current electronics knowledge. The first thing I'd like to do is add an xxPROM programmer to the IO lines so that I can fix my old much-loved EA DATUM. It appears to need a new ROM and several years ago its designer promised to send one but I never got it.

The second is that I've always dreamed of building a small, portable computer in the form factor of a portable game machine plus slide-out keyboard or PS2 socket and four USB ports. An SD or CF card slot would hide in the battery compartment (AA or C for long life).

I think that if I built a "Maximite 2" with a NewHaven (from **Jameco.com**) parallel LCD and the 100-pin PIC32, then I am well on the way. This is a HUGE project for my background and help from others would absolutely be loved. Software-wise, my preference would be a character-based menu system like the old QuickBASIC or free QBASIC.

I just hope Maximite will be a blockbuster for us all.

David Morton,
Geeveston, Tas.

crosswise. This means that as it crosses "the gate" in the projector, the centre is out of focus with the edges or vice-versa.

I suggest your readers contact "The Redcliffe Picture Palace" in Queensland for advice on their "Liquid Film Plasticiser". This treatment may take 12 or more weeks but with it you will be able to get consistent focus. Then I suggest you send it off to DVD Infinity and you will be thrilled with the results. I got great results from a 1948 standard 8mm film that had been badly warped.

Robert Armstrong,
Toronto, NSW.

Switching power supplies in DVD players have lots of EMI

I recently bought a Sony DVD/CD player (model DVP-SR700H). This unit is a marvel of compactness and economy, typical of the inexpensive and compact DVD players now on the market. However, it radiated so much radio frequency "hash" that it completely obliterated broadcast-band reception in a nearby radio.

The hash was even obtrusive in a radio in an adjacent room. Moreover, the hash was present even when the unit was not being used.

Remembering Mauro Grassi's article (SILICON CHIP, October 2007), I decided to build an old-fashioned external linear power supply. The internal circuit boards indicated a requirement for 15V and 5V supplies. I began using 7815 and 7805 voltage regulators, along the general lines described in the article but to my surprise and disappointment, the unit refused to work. By a process of elimination I traced the problem to the 5V supply.

Of course, I had no idea of the current required but the 7805 regulator can supply up to 1A. Surely this would be sufficient? But measurements with

Why are hearing aids so expensive?

I wonder why hearing aids are so expensive. In all other fields of electronic endeavour, costs have benefited through advancing technology but hearing aids seem to have missed out. For example, I bought the latest and best computer with LCD screen, with lots of software, as much memory as it would take, the largest hard drive available and a multifunction printer. The bill was $2349.01.

About 19 months later, I bought two hearing aids, digital but not the most expensive, and they cost $2400, ie, $1200 each! On top of that there were three consultations and two new ear moulds; a total of $2740.

There is a mystique that surrounds hearing aids which, after all, are quite simple devices compared with TV sets, computers, printers, cell phones, CD players and so on, despite the "clever" things that they can do.

Production volumes are probably quite small compared with a lot of consumer electronics but if each $1200 hearing aid was made by hand by someone being paid say $50.00 an hour, they would take 24 hours to make one aid. I doubt if this is how they are manufactured!

I think that people with hearing loss are "being taken for a ride" This is accepted by "little old lady" type people and others who are only too glad to get the benefit of hearing aids no matter what the cost. In New Zealand there is a Government subsidy available but the aids should not be so expensive in the first place.

Clive Singleton,
Lower Hutt, NZ.

Comment: you have already touched on some of the reasons why hearing aids are so much more expensive than typical consumer electronics products, most of which are mass-produced in Asia rather than being made in relatively small quantities in high-labour cost countries. We suspect that a major part of the high cost of hearing aids which are supplied and fitted by an audiologist is due to the fact that they have to be individually fitted and programmed.

*There is now a much cheaper user-programmable hearing aid available from Australia Hears (**australiahears.com.au**). We hope to do a review article on this in the near future.*

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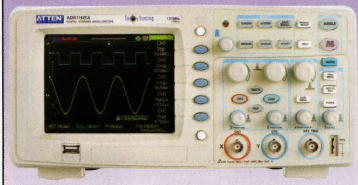

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Mailbag: continued

More on in-wheel motors for electric cars

I have just been reading letters to the editor in the April 0211 edition – in particular "Mitsubishi i-MiEV should have in-wheel motors" and saw your comment on connecting wheel motors in series and how does it let them run at different speeds around a corner, etc. Your correspondent is right!

I built a small remote vehicle having two wheel motors (in my case small permanent magnet DC motors) connected in series to a single speed controller. It gives a pretty good analog to a mechanical differential. If you want accurate speed control you can even connect the tacho outputs in series and feed that into the tacho input of your speed controller. If you have full tachometric feedback, the mechanical analog is almost exact.

It is easy to demonstrate the boundary conditions of differential action. Hold the wheels off the ground and they both run at about the set speed. Stop one wheel and the other one spins at twice the set speed (just like a mechanical differential).

In operation around a corner, the torque and speed of the two motors adjust to the differential speed requirements, just like a mechanical differential. It is impressive the first time you see it in action.

Dr David Hainsworth,
Mining Science & Engineering Program Leader, CSIRO Earth Science & Resource Engineering, Kenmore, Qld.

an external bench power supply showed that the peak current required was a little over 1.5A, well beyond the capacity of the 7805 chip. I replaced it with an LM350K regulator, which is capable of delivering 5V at up to 3A. Surely that would fix the problem? But the unit still refused to work. The power was being delivered but no joy. What could be wrong?

Finally, the penny dropped. More careful measurement showed that the original 5V switching power supply delivered 5.3V. As a general rule, the nominal 5V required by ICs is not very critical. I had assumed that 5.0V would suffice, but no.

A simple adjustment to raise the output of the LM350K regulator to 5.4V solved the problem!

The result – complete elimination of the hash, at a cost of about $100; about the same cost as the original player, plus the inconvenience of a bulky external power supply. The original unit is compact and economical but has cost-cutting been taken too far? Sony is a reputable brand and I had considered returning it under warranty but it was probably performing to specification.

Not all devices with switching power supplies produce this much radiation. There seems to be a need for more rigorous standards for electromagnetic radiation from switching power supplies. More filtering and shielding should do the trick and the additional cost should be minimal. I can't see us going back to linear power supplies.

James Goding,
Princes Hill, Vic.

Comment: that you had to go the trouble of building a bulky external power supply highlights the fact that switchmode supplies in cheap DVD players are simply unsatisfactory. More to the point, it makes nonsense of any EMC standards or C-tick approvals.

Cars with lights on high beam are dazzling

I have a concern over motorists who are using their high-beam lights with no thought given to other road users. I do realise this can happen accidentally; maybe car manufacturers could install another switch which disables high beam to stop this situation.

Sometimes I could swear that a vehicle approaching or behind me has the lights on high beam. This can be very dangerous in certain situations. Is there any way to meter another vehicle's headlight to prove to yourself whether their high beam is on or not? If different headlight technologies give out different light levels then maybe this is a another problem or maybe trying to meter at night from a distance makes it unworkable.

My other requirement is for an alarm for a fridge/freezer door when it is accidentally left ajar or open. This has happened twice to me just recently in hot weather while I was at work. So over the day I lost quite a bit of food and the poor old fridge was working very hard to no effect. I realise that un-

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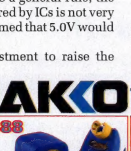

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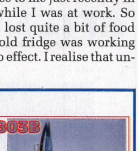

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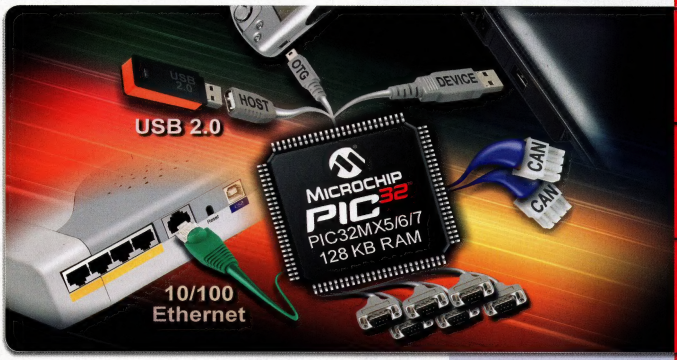

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Mailbag: continued

less someone is home to hear the alarm, the device would be fairly useless. Any suggestions ?

Mark Eastaugh,
Armadale, WA.

Comment: your letter raises a subject which is of interest to most readers, particularly those who are older. Night-time glare is exacerbated for older readers who have cataracts developing; everyone eventually suffers from cataracts.

It is true that some drivers are ignorant (or deliberately rude) and do drive with lights on high beam when facing on-coming traffic and when following other cars. Some cars with HID headlights also seem to have more glare than they should and they can be painfully bright. They are probably not correctly aimed. You don't really need a light meter to tell when a car has its headlights on high beam; if they're dazzling they are probably on high beam. And if they are on high beam, there is nothing you can do about it.

It is also true that cars with dirty headlights cause more glare than with clean headlight lenses, even when they are on low beam.

There are no electronic solutions but there are several things you can do to help minimise the problem. The first is to keep the windscreen, rear window and all mirrors of your own car as clean as possible. Dirt and grime add to the glare problem. Second, keep mirrors dipped to minimise the chance of being blinded by a car at the rear. Third, if you wear glasses you should have them anti-glare coated – it does help.

As far as your fridge is concerned, we featured a Fridge Door Alarm in the June 2004 issue.

More on memory size of flash drives

In regards to your comments on memory size of storage devices (Ask Silicon Chip, April 2011), whilst you're quite correct concerning the blatantly spin-derived advertising figures that you talk about, you neglected to mention that the capacity reported is also a function of the file system used and block sizes the device is formatted in, as every file system is optimised differently.

For example, a 500MB USB stick formatted with a FAT file system will return 515,612,672 bytes (using the default 8K block size) or about 491MB. When formatted with a FAT32 file system, it will return 514,854,912 bytes (using the default 4k block size) or about 492MB. When formatted with an NTFS file system, it will return 510,619,648 bytes (using the default 512-byte block size) or about 487MB. This discrepancy is more exaggerated in much larger devices.

Jason Ditcham,
Panton Hill,Vic.

Having a hot shower is almost considered a crime

In your Publisher's Letter in the April 2011 issue, you scoff at the statement, attributed to the "misguided government", that "every time you have a hot shower powered by electricity, you're using the same amount of energy that it takes to run 150 televisions at once".

What does that really mean and could it be true? Perhaps it suggests showering uses energy at the same rate as that which is required to run 150 television receivers. A "back-of-the-envelope" calculation confirms this, as follows: 150 TV receivers at (say) 200W each require 30kW of electrical power.

If it is assumed that a shower uses 10 litres/minute (ie, 0.17L/s) of water which has been heated from 10°C to 55°C (a temperature rise of 45°C), and that the specific heat of water is 4.2kW/kg/K, then the power required is 0.17 x 4.2 x 45 = 32kW, which agrees quite closely with the consumption of the TV sets.

Thus, although the government's statement might have been rather more carefully worded, it is essentially true. What was not mentioned in your editorial however, and is at the very heart of the problem of using electrical energy for heating, is the fundamental practical limit on the efficiency of power stations in converting the energy in the original fossil fuel, be that coal, oil or gas, to electricity.

This limitation is described numerically by the second law of thermodynamics and limits the maximum possible efficiency from such stations to about 30%. Thus the generation of electricity from combustion processes always results in about two thirds of the original calorific value of the fuel being wasted. That's why using electricity for

bulk domestic water heating is almost a crime!

Andrew Baghurst,
Port Elliot, SA.

Comment: the statement is still ridiculous and it is intended to make people feel guilty or as you say, "almost a crime". For a start, no-one has a shower with a water temperature of 55°. It would be too hot. Even if we accept that, say, 18kW is being consumed while you run the shower, then this is an argument for having a shorter shower, not for replacing a perfectly functioning hot-water system.

While you are correct in your assessment of using coal-fired electricity to heat water, it should also be remembered that most hot-water is heating is done at night when the generators are essentially on spinning reserve – they have to be run continuously in any case, whether water was being heated or not.

3-stage MPPT solar charge controller has minimal benefit

I would like to comment on this project, having just used it on a short camping holiday. While it is a nice 3-stage regulator, the MPPT feature is, as far as I am concerned, a waste of effort. Using an 80W panel and alternating it with a conventional regulator that has FET switching, the old style regulator almost always performed the same or slightly better.

The MPPT circuit seems to use around 5W and when the battery voltage is above 13V, the MPPT regulator is no better than a straight connection. When I test the unit on a power supply feeding it with 17V, the output current is always higher than the input, suggesting that it is working properly.

I might add that I have also owned a locally-made unit (the GSL 12A) and the results were much the same, the main advantage with the GSL being that you can use a 24V panel on a 12V battery without any adjustment.

Horst Leykam,
Dee Why, NSW.

Comment: for an 80W panel, the maximum power point (MPPT) should be around 4.44A at 18V. For a direct connection from the panel to a 12V battery, the current would be around 4.6A at 12V and 4.55A at 14.8V, ie, 55.2W and 67.34W respectively. It is true that for smaller wattage solar panels the benefits of MPPT charging are diminished. That's because the losses in the MPPT charger begin to match the extra power delivered compared to a direct connection to the battery.

For the 80W panel, the result when the battery is at 14.8V would be around 75W with MPPT charging, assuming a 5W loss in the MPPT charger circuitry, compared to a 67W charge for the direct connection.

At a battery voltage of 12V, the MPPT charger would be charging at 75W and the direct connection 55W. So the advantage is better when the battery is discharged.

USB port for PC high-current bench supply conversion

I found the article on converting an old computer power supply to a bench supply (SILICON CHIP, January 2011) to be very interesting and I'm just look-

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Mailbag: continued

ADSL Line Performance

Wiring	Line measurements					Average
Normal Cable	Actual line rate (kbps)	4357	4528	4450	4415	4437
	Attainable line rate (kbps)	4780	4972	4852	4840	4861
	Noise margin (db)		6.4	6.6	6.5	6.5
	Attenuation (db)		54	54	54	54
Crossover Cable	Actual line rate (kbps)	4850	4675	4780	4855	4790
	Attainable line rate (kbps)	5292	5124	5220	5300	5234
	Noise margin (db)	6.3	6.1	6.4	6.3	6.3
	Attenuation (db)	54	54	54	54	54

Phone polarity and ADSL performance

Your Phone Line Polarity Checker article made me wonder at first if I was reading the April edition of SILICON CHIP. Some of the points raised by David Drane appeared valid but I wasn't too sure.

Rather than building the checker I decided to experiment by connecting my Dynalink DSL modem to its central splitter/filter (and PSTN line) using a straight-through cable and then using a crossover cable. For each cable configuration the actual line rate, attainable line rate, noise margin and attenuation as reported by the modem was recorded after rebooting the modem. This was repeated four times.

The results confirmed David's article and showed approximately a 7% improvement of actual line rate; Not a big difference in the scheme of things but interesting that the line polarity does make a difference. My DSL service is at the end of a 3.5km line and I wonder what the results would be like closer to or further from the exchange?

Stephen Wright,
Wahroonga, NSW.

ing into doing one for myself, along similar lines to that described in the article. While considering just how to do mine, I came to realise that there is an important feature missing from the one described in the magazine and that is a 5V USB port, so I'm going to add one to my unit.

The way I am going to do this is to use an old USB add-on port that would have been connected to the motherboard and would have been fitted in one of the rear case slots. The port is attached to the backing plate with two screws. The port will be fitted in the power supply case and the two data wires will be cut off and the two power wires will simply be connected to the 5V power supply wiring, thus providing a 5V USB power port.

I thought this idea could be suggested as an after-thought for the original project.

Bruce Pierson,
via email.

Neck coupler could use telephone cable

I have a couple of suggestions regarding the physical design of the Microphone to Neck Loop Coupler for Hearing Aids from the March 2011 issue. Construction of the loop is a bit awkward because the constructor has to make and insulate all those connections as shown in Fig 3. Also, since the loop is unbroken, the user will have to slip it over their head, which could mess up one's hairdo.

These problems can be eliminated by making the loop using 4-conductor telephone cable complete with a modular connector at each end. Put two modular sockets on the PCB. All the loop connections can then be made on the PCB. The user can then put the unit on or take it off by inserting or removing one of the modular connectors from its socket. The loop would then only need to be big enough to go around the neck rather than having to

be wide enough to go over the head and hair.

In fact, only a single modular socket and plug are really needed and the other end of the loop cable can be soldered directly to the PCB. This would have the advantage that constructors could simply snip the desired length off one end of a pre-made telephone cable, without having to use a special tool to crimp a modular connector at the cut end.

Further, if the loop could be made to work with just three conductors, the fourth conductor could be wired in series with the battery so that the unit is automatically turned off when one end of the loop is disconnected. Power switch S1 could be retained in case the user needs to turn the unit off without physically removing it.

Andrew Partridge,
Toowoomba East, Qld.

Comment: this seems like a good idea. However, the smaller the loop the less effective is the coupling to the T-coil in the hearing aid. Also, if wired with three conductors and using the fourth conductor as the battery connection, the effectively shorted power loop may affect the signal loop performance.

Feedback on phone polarity checker

I read with interest the article on the Phone Line Polarity Checker (SILICON CHIP, May 2011 and decided to check out my new home.

I made up a checker from loose parts and then found great difficulty in finding out which is pin 1 of the three RJ12 female sockets in my house. Nevertheless after much internet searching, I made the assumption that by looking at the socket with the locking/locating tab down facing, the connectors at the top would number left to right, ie, pin 1 to pin 6.

Therefore, as you say, pin 4 should be positive with respect to pin 3 but it isn't in my house. I then went to my modem (2-Wire 2017-A) set-up and noted that the settings there were: Downstream Rate = 11,423 kbps, Upstream Rate = 810kbps, Current Noise Margin = 12dB (Downstream) 12dB (Upstream), Current Attenuation = 39dB (DS) 21dB (US) and Current Output Power = 19dbm (DS) and 12 dbm (US).

So assuming the worst, I swapped the cable with a crossed cable to see what the change in polarity would do. But this had little effect as the settings were much the same. Hence it seems my modem doesn't care about line polarity.

In this exercise I managed to drag out of my box of tricks about half a dozen old Series 600 to RJ adapters, and found that they were not all the same pin-for-pin configuration, with some reversing the wiring. This shows that it is no wonder that some people are having issues with polarity.

Brian Collath,
Moss Vale, NSW.

More on phone polarity and ADSL performance

Wow – thanks for the Phone Line Polarity Checker! I have long suspected that my broadband connection was slower than it should be and had thought it was because we were near the distance limit from the exchange. With the Checker I was able to discover that the cable into my modem produced a red light and when replaced with another cable that produced a green light my internet speed was significantly faster.

With faster broadband and the DAB+/FM Tuner playing magnificently in the corner, what more could a chap want? More great projects of course! Love the magazine – hope it never stops.

As a postscript to my original email, further investigation has shown that the original phone cable to the modem was wired correctly and that the polarity reversal occurred in the phone line transient protector in the power board I am using. It just so happened that when I replaced the original cable the replacement phone cable was apparently not wired correctly resulting in a reversal of the polarity back to what it should have been! Anyway – I now have a green light at the important part of the cable train.

David Hebblethwaite,
Maleny, Qld.

Phone polarity has no effect on ADSL

I was mystified to read the article on the Phone Line Polarity Checker for ADSL in the May 2011 issue of SILICON

Mailbag: continued

Mitsubishi i-MiEV and in-wheel motors

Thanks for publishing my letter in the Mailbag pages of the April 2011 issue. Leo Simpson's comments were as usual thought-provoking. However, they have led to me doing some more research on-line and coming up with some suggestions about solving the problems with my favourite "in wheel" motors.

Firstly, almost all modern cars already have a lot of electronics on board so perhaps it would not be a great problem to modify the systems of accelerometers, etc to sense cornering and feed power to the motors appropriately. The ABS system basically does the opposite with the brakes already! All we have to do is to use the accelerometer information to control the PWM controller for each motor with some input from the steering system.

My reading tells me that an electric car designed by Michelin in France back in 2009, with in-wheel motors, claimed an unsprung weight of 35kg on the front wheels and 24kg on the rear. According to the same source, the "Clio" petrol car has an unsprung weight of 38kg. Unless my source is wrong, where is the problem?

I must confess though that my estimate of power loss in the differential was far too high. In practice, a loss of 5% looks about right but the weight loss remains the same!

So we may not be saving so much energy but we are saving many kilograms of vehicle weight which can be used for increased battery storage.

Many of your correspondents in the same issue are obviously Jeremy Clarkson fans, (don't tell my wife – she can't stand him) but very sorry folks, soon your V8s and V12s are not going to have any more fuel or you'll be fighting continuous wars over what's left. As Bob Heinlein said "Natural laws have no pity".

Is anyone prepared to give some thought to a suitable motor control system?

Clifford Wright,
Helensville. NZ.

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CHIP. I was unaware that line polarity had any effect on DSL operation or data speed transmission.

It is a requirement that all customer equipment connected to the Australian PSTN must function as intended regardless of line polarity – see **www.commsalliance.com.au/__data/assets/pdf_file/0012/2505/S041_2005r.pdf** and **www.telstra.com.au/adsl/docs/adslcpe.pdf** (para 5.6.3).

The telephone line is a balanced signalling line with the positive leg of the line single point earthed at the exchange end only. If a DSL modem/router experiences data rate degradation when the line is reversed then the modem itself is the problem, not the phone line. The fact that there is 48V DC on the line should not affect the performance of the DSL equipment no matter in which direction any DC current is flowing in the DSL interface arrangement.

I agree that there is a possibility that practice and theory will not always agree. However, apart from a few references in forums on the web (having relevance to the Australian PSTN), the issue of line polarity and ADSL performance hardly rates a mention. I would have thought that if line polarity were a problem, as claimed in the SILICON CHIP article, there would be numerous mentions, reports and warnings. I can't even find any confirmed reports of problems when searching the web for any part of the world; quite the opposite in fact.

In this forum **http://forum.kitz.co.uk/index.php?topic=999.0;wap2** Setecio tried reversing the line and found no difference in data transmission speed.

I have a friend who until recently worked on providing ADSL services for Visionstream and he is adamant that polarity is not an issue. He even says that ADSL will get through even if one leg of the line is open-circuit.

Fig.4 in this article **http://www.eetasia.com/ARTICLES/2000FEB/2000FEB01_NTEK_TA.PDF** shows a typical ADSL full duplex transceiver (and that is 10 years old) and it can be seen that as far as the telephone line polarity is concerned (T & R connections) it will make absolutely no difference which way around the line is connected. DMT signals used by ADSL are not affected by line polarity since there is no DC current in the hybrid interface transformer/s.

Without wishing to be flippant, I challenge you to find any confirmed reports where polarity alone has been the cause of poor ADSL transmission speed. I guess your time is too important to waste and it is of little importance in the grand scheme of things anyway. Who cares if SILICON CHIP readers actually believe that line polarity is a problem? At least they may go out and buy a kit to build the checker.

Ross Herbert,
Carine, Qld

Comment: we can vouch for the fact that ADSL can get through when one line is open-circuit; two SILICON CHIP staff have recently had ADSL working while their phones were out of order. But it also appears that phone line polarity can affect performance. SC

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At last! An Energy Saving Device that ACTUALLY DOES save energy!

by ROSS TESTER

FUTURE WAVE™ ENERGY SAVER

During the past few years, SILICON CHIP has exposed some decidedly "shonky" power-saving devices. So it gives us great pleasure in "exposing" another power-saving device . . . one that actually lives up to its claims. The FutureWave Energy Saver WILL save energy and therefore money. And we have the test figures to prove it.

We **first saw this device** on one of the tabloid TV shows late last year. Typical of these shows, the report was full of "gee whiz" and short on substance. We wondered if the claims being made were real . . . or was it just another in the long line of power saving devices which don't quite stand up to a technically-sound examination.

Developed by a couple of electric motor rewinders in a shed on Queensland's Sunshine Coast, the FutureWave Energy Saver was claimed to reduce electricity consumption by a rather significant amount. They claim up to 80% – a figure we can't quite replicate – but the savings we can measure are not too far away.

But we are getting a bit ahead of ourselves. Shortly after we saw it on TV, we tried to contact FutureWave via their website and emails – without a lot of luck. It turns out at the time they were simply too busy trying to keep up with demand following their TV exposure to have even more media exposure – which could further increase demand.

But we persevered, eventually tracking down a mobile phone number which was not only answered but we were promised that someone would get back to us within a week or two. It was explained to us that FutureWave had moved to new premises and significantly ramped up their production capacity, so now they were happy to talk to the technical media which would put their device under much more scrutiny than the TV programs had.

They were well aware of SILICON CHIP (in fact they subscribed) – so were also well aware of the damning reports we had published on previous "energy saving" devices. More to the point, they completely agreed with us!

But they were also very quick to point out that the FutureWave device went about its energy saving task in a completely different, scientifically proven way (more on that anon) and it was also specifically intended for certain electric motors, the main target market being swimming pool and spa pumps.

They were confident that FutureWave Energy Saver would stand up to SILICON CHIP's scrutiny and measurements.

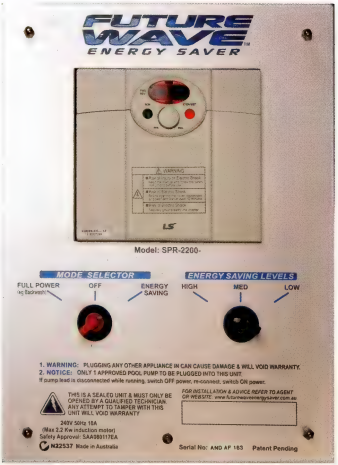
In due course, a FutureWave Energy Saver was delivered to the SILICON CHIP office. Yours truly was given the task of reviewing the device, mainly because I happen to be the only one with a swimming pool in the back yard!

The FutureWave Energy Saver

It's housed in an ABS box measuring 390 x 300 x 150mm. The lid of the box is clear and hinged, opening to allow access to a limited range of user controls. There are two large 3-position switches, one of which selects the mode of operation – full power (used, for example, when backwashing a filter), energy saving (ie, controlled by the unit) and off. The second switch selects the amount of energy saving – high, medium or low.

There's also a small knob which appears to vary the amount of time the FutureWave remains in its various modes, along with a couple of small pushbuttons which, while labelled "run" and "start/stop", have uses which were not immediately obvious. Perhaps these are explained in the operation manual which, unfortunately, our test unit did not come with.

Above these controls is a LED display which gives a readout of the pump supply frequency, which varies according to the energy saving setting.



User controls on the FutureWave Energy Saver are minimal: two large switches controlling mode and energy saving level. Without instructions, we were unable to work out the controls at the top but the LED display reads the frequency supplied to the pump motor.

There's a 230V AC mains input cable and, on the underside, a 230V AC mains socket, into which your pool pump plugs. And that's just about it as far as the user is concerned.

How it works

The FutureWave Energy Saver is based on the assumption that the vast majority of pool pumps are more powerful than they need be for proper filtering of the water.

There is a very good reason for this – no pool pump is used continuously (apart from wearing the bearings out, the cost of electricity would be prohibitive). But the pump almost invariably needs more "grunt" whenever it is started to overcome the initial resistance of the filter and getting the water flowing through it. The amount of power needed depends to a large degree on the type of filter.

But once operating, the pump doesn't need to keep pushing that amount of water through the filter – in fact, there is some argument to suggest filtration is better with the water flow just enough to pass through the filter medium. FutureWave themselves have published several field tests, both in large public and smaller private pools, which show no deleterious effects in pool water quality by using their device with lower flow rates.

So what we normally have is a powerful pump pushing too much water through a filter; a pump that uses a quite

The FutureWave Energy Saver is perfectly suited to do-it-yourself installation. There is no plumbing or wiring to install: all you do is unplug your pool pump from its mains socket, plug it into the FutureWave and then plug the FutureWave back into the mains socket. If (as would be the norm) your pool pump operates via a time switch, the FutureWave plugs into it. Installation complete!

significant amount of power at start-up, then continues to gobble power as it runs at too fast a speed.

How much power?

A typical pool pump for a 50-70,000 litre pool (ie, a reasonable-size backyard pool) would be rated at about 1kW (~1.3hp). If the pump is run for a typical five hours per day during the swim season (depending on location, say 7-8 months, more with heating) that could be as much as 1000 x 5 = 5kWh x 265(days) = ~1250kWh.

Add to that the pump/filter use during the off-season (most pool owners would drop it to about 1-2 hours per day) and you could add another 180kWh, or about 1430kWh for the year.

At the current (at time of writing - see www.energyaustralia.com.au/State/NSW/Residential/Products-and-services/Electricity/~/media/Files/Residential/Pricing/2010/NSW_RES_PL.ashx) electricity rate of about 28c/kwh, your pool pump alone is currently costing you about $400 per annum. (Remember the high usage of a pool pump is likely to push you into the highest "balance per quarter" rate which cuts in at 1750kWh/quarter). Even at the sub-1750kWh rate (~19c/kWh) you're still up for the best part of $300 per annum.

And that's before the looming electricity price hikes (~18%?) – and, if it ever happens, a carbon dioxide tax.

Wouldn't it be nice to cut that down by half, or even three quarters? And at the same time, save in pump wear and tear, noise and (if it is important to you), your carbon footprint. That's what the FutureWave Energy Saver promises.

But does it deliver – and if so, how?

According to FutureWave Energy Solutions, the Australian developers of the FutureWave Energy Saver (they're based on the Sunshine Coast of Qld), this is how:

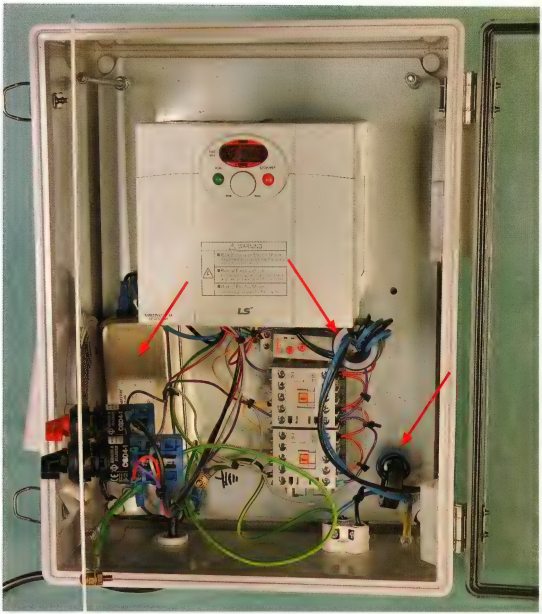
"The Future Wave Energy Saver will soft start the pump motor, removing the huge initial start up demand of electricity. This start up process will take about 20 seconds to initiate. The pump will then operate at close to its normal rate for another 20 seconds while it primes the pump. When the pump is fully primed there is no need for it to draw so much energy to work effectively so the Future Wave Energy Saver will then wind the motor down to the energy saving level selected, saving significant amounts of electricity."

That's an interesting comment: "wind the motor down". The way it does this is the basis of the system.

The FutureWave Energy Saver is, quite simply, a variable-frequency motor drive. In fact, the device is based on a purpose-designed VFD (a SV02iC5-1 module, made by LS Industrial Solutions of Korea).

This module will handle up to 2.2kW (3hp) motors so the FutureWave is capable of handling the largest domestic pool and is, in fact, now being used at quite a few large community pools. Incidentally, according to specs we found on the 'net, this particular LS VFD module can also be used

The FutureWave Energy Saver is based on a Variable Frequency Driver (VFD) which has an H-Bridge output to drive the induction motor at reduced speeds. In effect, the VFD switches the H-Bridge output devices (Mosfets or IGBTs) with a high frequency variable pulse width signal to synthesise a low frequency sinewave (more or less) at 50Hz (full power), 38.5Hz (low saving), 35.5Hz (med saving) or 31.5Hz (high saving). These scope waveforms show the actual signal delivered to the motor and as you can see, there is a considerable high frequency component still present. This does not affect the motor's behaviour but it can cause AM radio interference (depending on the signal strength in your area).



Inside the FutureWave Energy Saver, with the front panel "folded back" 90°. The large module at the top is the Variable Frequency Drive (VFD) module which is the heart of the system. The large silver EMI suppressor (behind the switches) and the two toroid rings through which the power lines pass (all highlighted with arrows) should be capable of minimising radio frequency interference. They don't work real well in low signal areas!

to convert single-phase AC to three-phase (but of course, this feature is not used in the FutureWave application).

As you no doubt know, the speed of an AC induction motor is "locked" to the mains frequency – in our case, 50Hz.

Ergo, if you vary the frequency, you vary the speed of the motor. As long as you continue to supply sufficient voltage to keep the motor spinning, it will happily run at the lower speed.

In a nutshell, this is what the FutureWave Energy Saver does – it varies the supply frequency. The clever bit, at least as far as we are concerned, is in the programming – what length of time do the various modes keep running and of course, at what frequencies.

Table 1 below shows the theoretical rotational shaft speed of a (typical) 2-pole induction motor at various frequencies.

Note that this *is* theoretical – for a number of reasons, to do with slip and load, the actual speed of the motor will be less than this. Typical 50Hz 2-pole pool pump motors, for example, will have a nameplate rating of about 2800-2850rpm, or about 5% less than the synchronous speed.

So where does the power saving come in?

It's quite simple, really: run a motor at its normal (rated) speed and it uses maximum power. Maximum power equals maximum energy cost. Slow the motor down and, as long as it can continue to do the work required, the power (and therefore energy cost) decreases.

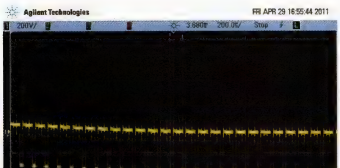
There does comes a point, however, where the motor will start getting rather cranky at running too slow. Heat dissipation from the windings can become a major problem (most induction motors have fans built in to assist in cooling), as does actually being able to supply enough "grunt" to run the pump or whatever device the motor is turning.

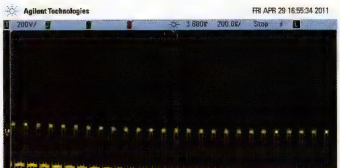
Soft-starting the motor

Another thing that the FutureWave does is "soft start" the motor. A rule-of-thumb is that starting current of an induction motor is around 500% of run current. This only lasts for a short time (perhaps half a second or so) until the motor is up to speed but in this time there is obviously a lot more power being used. By preventing this huge current at

Frequency (Hz)	Shaft rotational speed (rpm)
50	3000
40	2400
30	1800
20	1200
10	600

Table 1: Synchronous motor speed versus frequency





These two scope waveforms are taken at a much higher sweep speed (200us/div) than those overleaf to illustrate the variable pulse width of the synthesised motor waveform. The waveform with the high pulse duty cycle is delivered on positive excursions of the waveform while the low pulse duty cycle is equivalent to the negative duty cycle.

start-up, you're going to save money. Incremental savings, perhaps – but they all add up!

Wear and tear

Running a pool pump for several hours means it will get rather hot. You only have to see the large fins on most pumps to see that efforts are made to get rid of this heat.

It's the pump bearings which normally wear out first and if left unattended, or unnoticed, may cause the motor to seize, overheat and ultimately burn out.

Running the motor slower will result in cooler bearings, which in turn will result in longer bearing (and therefore motor) life.

Our testing

We did two different sets of tests – one in our laboratory, where we were able to capture the scope waveforms shown here, while the second was done "in the field" using a real pool pump on a real pool.

The lab tests showed the unit worked and did exactly what it was supposed to.

But there was a real sting in the tail – it was very difficult indeed to sync the scope on the waveform due to the large amount of noise on the waveform. The screen grabs show what we are talking about.

Our lab tests also showed that the voltage delivered to the pump was also reduced, along with the frequency. While nothing like a sine wave, we were able to get the scope to give us "RMS" voltage readings for the three different settings. These are reproduced below with the consumption readings.

Our "real world" test setup was quite simple: we used a 1.3hp pump already installed on a 50,000 litre pool. In line with the 230V power outlet (ie, before the pump) we placed a SILICON CHIP Energy Meter (see July 2004 issue) which gives an instantaneous reading in watts plus a cumulative reading in watt-hours (or kilowatt hours).

We then ran the pump "as is" for two hours, then five hours. The two different periods were to not only ensure statistical accuracy; the higher run time is typical for a domestic pool in summer and the lower typical for winter use.

These two readings were entirely consistent with what we would expect:

Full power: 2 hours - 1.964kWh 5 hours - 4.953kWh
(Power reading after "settling down" 1.01kW)

Then we placed the FutureWave Energy Saver in line and repeated the tests, with the energy saving level set to all three positions in turn (via the switch on the front panel of the unit). Remember, the "high" position is actually the highest energy saving, or in fact the lowest power setting.

As we mentioned earlier, we weren't able to duplicate the 80% power savings claimed by FutureWave Technologies. But we were able to demonstrate quite significant savings, more than enough to justify the claim of an "energy saving device":

High: 2 hours - 675Wh 5 hours - 1.7kWh
(Power reading after "settling down" 353W)
Frequency: 31.5Hz
Pump voltage: 122V (RMS)

That's a 66% reduction in power and is almost the same percentage reduction for both 2 hours and 5 hours, again as we would expect. As we said, not 80% but certainly getting up there and certainly worthwhile.

We repeated the tests with the FutureWave set to medium and low energy saving levels and the results were, of course, not as good but good nevertheless:

Medium: 2 hours - 975Wh, 5 hours - 2.42kWh
(Power reading after "settling down" 486W)
Frequency 35.5Hz
Pump voltage: 140V (RMS)

Low: 2 hours - 1.15kWh, 5 hours - 2.74kWh
(Power reading after "settling down" 575W)
Frequency: 38.5Hz
Pump voltage: 161V (RMS)

One point to note: running the pump through the FutureWave set to "Full Power" consumed 55W more than running the pump direct from the mains, so this is the FutureWave's "overhead" and also should be taken into account when calculating power savings. Of course, running the system through a mains time switch would mean no overhead for

FutureWave comments . . .

Silicon Chip provided a copy of the review to FutureWave prior to publication, for any comment. Rather than amend the original article, we decided to publish their response verbatim for readers to consider. Here's what they had to say:

Hi Ross,

Thank you very much for forwarding the article. We were very glad to see that the Future Wave Energy Saver performed as expected when running on a smaller 1HP (0.75kW) pump such as your pool pump Ross.

From our perspective we would like the opportunity to provide some feedback regarding some of the comments and findings in the article.

1. Firstly to clarify the structure of the companies – The inventors/developers & manufacturing side of things is through 'Future Wave Innovations Pty Ltd'. Our company 'Future Wave Energy Solutions Australia Pty Ltd' work direct with the manufacturers as the client facing sales side. Currently there are only a few smaller Re-Sellers out there but within the next few months there will be a proper robust Distribution Network put in place with a view to rolling out a nationwide accredited Reseller Network. So, just clarifying, we (Future Wave Energy Solutions Australia Pty Ltd) should not be referred to as the 'Developers'.

2. I wasn't made aware that the Future Wave had turned up without an instruction manual and had we been made aware of this we would definitely have provided one immediately. I have attached a soft copy of the information and instructions that are included with every Future Wave. The Future Wave that was redirected to Silicon Chip was one that was already sent to a customer in Sydney to trial and instead of sending it back to us in Queensland we thought it easier to have it sent on. Obviously they did not send it with the provided instructions etc. The buttons and dial that is referred to in the article are only used for the initial programming of the Future Wave after which they are programmed out so that no tampering can occur. In some 'Custom' cases the 'Medium' setting on the energy saving dial may be programmed to be variable and then the dial on the VSD would be used to adjust the frequency of the unit with Maximum and Minimum parameters set so the user can't inadvertantly do any damage.

3. The article makes comment on the claims of 'up to 80% savings' but the Silicon Chips test results showed results in the high 60's. This should be clarified that when we refer to 'up to 80%' it obviously means only in some cases. Results will vary for every pump depending on the size of the pump, load, make, model, age of the pump etc. The higher saving results are normally seen on larger pumps (1.5kW-2.2kW) and typically when running smaller pumps like the one tested (0.75kW – 1.0kW), we typically see closer to the 70% savings on average when running on the 'High' energy saving level. So we would say that your trial performed as we would have expected.

4. When referring to 'typical pool pump size' I think it is dangerous to say that for a 50,000 litre pool that a 1kW pump would be the norm. Pool pump sizes vary considerably depending on many factors, volume of water, filter design, complexity of the hydraulics, required turnover rates, climate, type of cleaner and so on. If I was having a guess for our climate in S-E Queensland and what would be typical, I would be estimating closer to a 1.5kW (2HP) pump would be the norm and a lot closer to what we generally see when selling or installing the Future Wave. Smaller pools under 50,000 thousand litres would typically utilise smaller pumps as you mentioned.

Also the reference to 'typical five hours per day for the swim season' as the general amount of time that an average pool pump would run also should be questioned. For a 50-70,000 litre pool through a warm to hot summer and the pool being frequently used, five hours would be dangerously close to the bare minimum that it should be running. Once again depending on many variables, pool size, pump size, climate, exposure, usage, type of filter, type of chlorinator, plumbing design etc. etc. this will vary considerably. I think you will find that generally any pool designer or pool maintenance professional will recommend running your pool for up to eight hours for water quality and hygiene purposes, especially on a 50-70,000 litre pool.

The further reference of '1-2 hours run time in the off-season' would be a very small minority of pool owners. There are over 500,000 pool owners in Queensland alone and the vast majority of these pool owners would be running their pool pumps for 3-5 hours at minimum throughout our small off-season, with a lot of pools now having solar water heating you will more than likely find that pools are being used year round and the pumps would be still running closer to 6-8 hours.

5. Point 4 above will obviously have an impact on 'typical savings'. You refer to a payback term of two years through savings. Once again this will not be the case for everyone but in some cases we frequently see payback periods under two years. This will obviously be when pool owners have larger pumps than the one you tested and they run for more hours a day. I think we should make it clear that with your test scenario used of two hours run time in winter and five hours in Summer on a smaller pump of 1kW we would not expect to see a two year ROI. On larger pools running larger pumps and running for eight hours or more a day then you will obviously see much better savings and payback periods. A fairly typical pool pump in Queensland of 1.5kW running eight hours a day on peak tariff of $0.2135per/kWh would be $233.00 per Quarter or $932.00 a year. At 70% savings this would mean a $653.00 saving per annum. At the price of $1295.00 this equates to pretty close to a two year payback period even if electricity prices were not to increase, but we all know this is not going to be the case and we will expect to see some pretty hefty increases meaning higher savings and a better payback period again.

6. Your findings of AM interference is a known issue and that is accepted but with thousands of units being currently used we are only aware of maybe a couple of individual instances that this has been an issue. The Future Wave Energy Saver passes all relevant Australian EMC standards and compliances. Further testing and development is being carried out with a view to address this concern. In individual cases where this is an issue we are happy to work with the customer to have it resolved. The quoted comment of 'no-one listens to AM anymore' is obviously used out of context and should be removed as I was the person who light-heartedly made that comment and I was quick to acknowledge that it was a known concern and that the designers were working on a fix and that I would take the findings directly to the designers to make comment on. We have been more than accommodating with giving Silicon Chip 'free reign' with their access to the Future Wave Energy Saver and ability to test it along with being available for comment and feedback and we think that this comment and the context of the paragraph makes us sound arrogant and dismissive of the issue which we clearly are not.

Overall we are obviously very happy that the unit tested well and the results are mostly positive but we would greatly appreciate the above comments be given consideration.

Kind regards,

Charlie Notting
Future Wave Energy Solutions Australia Pty Ltd

most of the time (ie, whenever it is off, it is OFF!).

Power cost

Let's translate that energy usage into the language everyone understands – dollars – using the same rates we used earlier.

Again, we are using the "high" setting. 1.7kWh per day times 265 days (summer) times $0.28; plus 675Wh times 100 days (winter) times $0.28, brings your annual pool power bill down to just $145.00. The lower energy usage may well keep you under the 1750kWh "premium rate" so you could even be paying around $98 per annum. What were those "full rate" figures we quoted earlier? Hmm: $400 and $300!

Noise

Here there is good news and bad news. The good news is very good and the bad news is, at least in my case, awful!

First of all, let me say that my pump is about five years old so by this time, you might expect quite a bit of bearing noise. Such is definitely the case: with the pump running on full power, we measured it at 79dBA @ 1m and 65dBA @ 5m, against a Sunday morning background level of 47dBA.

That's loud enough to be quite noticeable during the day but it's unacceptably loud during the still of the night. In fact, many councils have ordinances which prevent pool pumps being run after 9 or 10pm or before 6am – a time when many people on "smart meters" would prefer to run them to take advantage of significantly lower tariffs.

The good news

With the FutureWave Energy Saver in line and operating at its best saving rate, the noise level dropped to a much more satisfactory 72dBA @ 1m and 57dBA @ 5m. That's probably still too loud for night-time operation although, with a newer pump, it would obviously be significantly lower again. A modicum of sound-proofing around the pump may be all that is required. On the mid and low settings, noise was (respectively) 74dB/76dB @ 1m and 58dB/60dB @ 5m.

The bad news

If you like to listen to AM radio and you don't live in a relatively strong signal area, forget about using the FutureWave Energy Saver (at least as it is currently configured).

Let me explain that: while I'm only about 20km from the centre of Sydney, radio and TV signal levels at my place are renowned to be low, mainly due to topography.

I would equate the level of signal as akin to that of a country town, where the "local" radio transmitter can be many kilometres away; perhaps even several towns away (and may be fairly low power into the bargain).

My pool pump is virtually on the back boundary of my property (a standard 15 x 45m suburban block). My house is set well forward on the block.

No AM radio reception was possible anywhere in the house or yard when the FutureWave was turned on – in fact, my partner has never moved so fast, to turn any radios off when that "damnawful noise" started! I'm not simply talking about mains-powered radios where the interference could have been introduced via the mains wiring. I'm also talking about interference on a battery powered portable, not just on my property but right across the road – a distance of about 65 metres from the offending noise source!

I wasn't game to ask my next-door neighbours if they had the same problems as I (they'd know who to blame!) but clearly if I was having reception problems at 65m, the odds were pretty good (or is that pretty bad?)!

The FutureWave does have EMI suppression built in, as our photo clearly shows. However, it just as clearly is inadequate if your AM radio reception is not strong.

I mentioned this problem to FutureWave after my tests and they were aware of the problem but were, if not dismissive of it, didn't think it too big a problem. Their comment: "no-one listens to AM radio any more . . ." I've got to tell them that this little black duck does, as do many friends and colleagues.

They did say that the designers were aware of the interference problem and were working on a "fix". I hope for their sake the fix is quick – otherwise I suspect that many users, especially in country areas will say "bugger the savings – I want my radio reception back."

How much?

It's not easy to get a price for the FutureWave Energy Saver. Everyone wants you to contact them and they will get a "representative to contact you" who will then tell you the price. Perhaps the reason for this is that it is sold through a variety of on-sellers who may wish to provide extra services at installation (particularly if they are pool shops, etc).

But the FutureWave Energy Saver doesn't need "installation" as such – it is quite suitable for the do-it-yourselfer to put in (how hard is it to unplug the pump power lead and plug it back in via the FutureWave?).

So many readers may want a "supply only" price, as distinct from a "supply and install".

We believe the "supply only" price is around $1295.00 – at least, that's the only price we could find on the 'net (there were plenty of suppliers offering the FutureWave but with only one exception that we could find, all remained pretty coy about how much it cost. Most simply claimed that you would save the cost back in two years, or words the that effect).

Incidentally, we have a bit of a problem with that particular claim. As we noted earlier, two years at full electricity tariff is about $800; our measurements suggest two years with the FutureWave is at best about $180. The difference is a bit over $600 – a fair way short of the $1295 FutureWave cost. Four years? Now that's a different proposition.

Conclusion

OK, the FutureWave Energy Saver clearly works and will clearly save energy. With electricity prices slated to increase yet again this month, that saving can only be a good thing and will reduce the payback period of the unit.

Just how much you save also depends on which setting you run the FutureWave on, the length of time you run it (eg, does it keep the pool clean?) and whether or not you can take advantage of lowest electricity tariffs. If all your ducks line up, the savings can be quite significant.

However, until that interference problem is fixed, anyone with a FutureWave, especially in the country but even city dwellers who don't have strong radio signal levels, may well run into AM radio reception problems – if not themselves, with neighbours up to three houses or more away.

For more information on the FutureWave Energy Saver, and a list of suppliers, visit the company website, www.futurewaveenergy.com.au, or call Futurewave Energy Solutions Australia on 1300 979303. Postal address: PO Box 577, Mooloolaba, Qld. 4557

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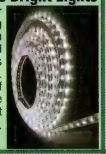

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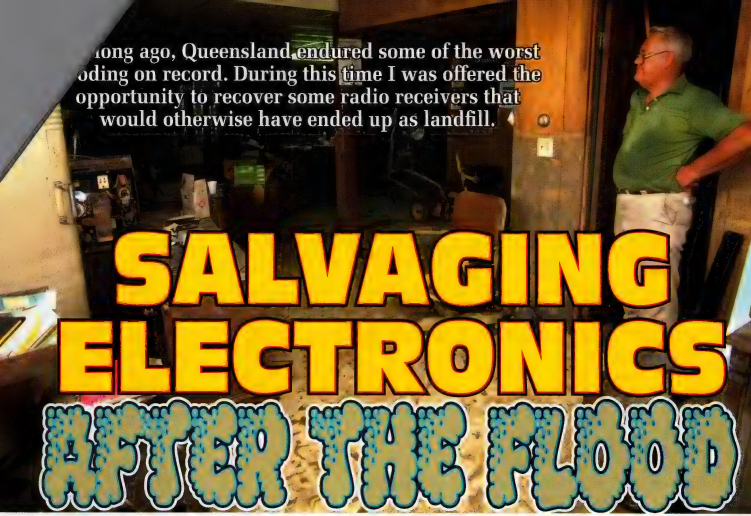


long ago, Queensland endured some of the worst oding on record. During this time I was offered the opportunity to recover some radio receivers that would otherwise have ended up as landfill.

SALVAGING ELECTRONICS AFTER THE FLOOD

The equipment concerned was ex-Army communication receivers, Rohde and Schwarz ESMC 0.5-650MHz, about fifteen years old. The receivers were stored in a shed that that went to the roof in floodwater and remained so for a day or two.

The owner had picked them up at auction and was in the process of selling them on a popular internet auction site.

Electronics gear, especially the older stuff, is like artwork – its beauty is in the eye of the beholder.

Where some would have turfed these straight on the scrap heap, the magpie nature in me couldn't resist a challenge. Rohde and Schwarz equipment is well built and has a good name, so I picked up six of the better looking units to take home and repair.

The rest were consigned to the pile of ruined memories on the footpath outside, like the contents of so many other flood-affected houses in our area.

If you are going to try this sort of flood recovery of electronic equipment you need to pick your targets. Some things, like speakers and gear with non-removable batteries can be a lost cause.

As with most flood events, the effects on equipment change with many different factors. Floodwater might be clean, like rainwater runoff or a broken pipe; the flood event may only last a few minutes or even seconds.

In this flood, the water was brown, silt-laden (and who knows what else) and lasted a day or two, the water backing up a small creek that led to the local river.

The longer gear is submerged in the flood water, the more it will accumulate silt and muck. The last local flood of this calibre was in 1974 and most places were flooded for a week or more. After that length of time immersed in flood water, equipment recovery gets very difficult.

Each situation requires its own assessment as to the worthiness of an attempted recovery and special consideration needs to be given to high voltage and mains-powered gear.

Never try to power up electrical equipment that has come in contact with water until it has been fully checked by a suitably experienced person.

And remember your personal hygiene: flood water can contain all sorts of contaminants, from industrial chemicals to raw sewage. If you are at all suspicious about any contaminants, use gloves and wash your hands! Even a face mask might not go astray.

Having never really attempted flood recovery before, it was time to sit down and have a think about how to go about this.

More speed, less haste!

Time is the enemy but I had other commitments for a few days and could not begin the rescue process straight away. So the first thing I did was take freely available oxygen out of the equation – the less oxygen available, the slower the corrosion process.

How would I do that? Well, counter-intuitive as it may seem, I drowned the equipment/gear again.

I figured that if I could cover the receivers with clean and (almost) ion-free water from our rainwater tank, I

by Robert Googe

Just as they were about to be auctioned off on the internet, the once-in-a-lifetime flood decided to wreak its havoc (for the second time this lifetime!). Some of these Rohde and Schwartz receivers were consigned to the scrap heap . . . but I couldn't resist having a go at trying to clean some of them up and get them going!

could achieve several things; give the gear/equipment a good flush of clean water, removing some of the silt and reducing the oxygen availability that would have been higher in air.

Initially I was stumped as to how I was going to achieve this, as these units aren't exactly on the small side, about as big as a size 13 shoe box (yes, I should know!). Something large enough to completely submerge them, obviously water tight . . . Then it hit me, a wheelie bin!

So the contents of our recycling bin went onto the ground, the receivers were stacked up inside and the bin was filled with water from the tank.

Check for batteries!

It was just as I finished filling the bin, I realised there was something I needed to do. The first thing I should have done was to check for batteries and disable or, preferably, remove them.

Batteries in water accelerate corrosion by electrolysis, so removing them is essential. That's why so many "I-xxx" devices made by that fruit company (as Forrest Gump called it) do not survive immersion – the (non-removable) battery voltage kills circuitry by corroding, or by the voltage being in places it shouldn't thanks to moisture.

Quickly pulling apart one of the units, I found there was a rechargeable Nicad backup battery on the processor board. I did not have time to remove each battery but it was a simple move of a jumper to take it out of circuit. This was done for each unit.

The other enemy is bi-metallic corrosion. This is where two dissimilar metals can set up an ion flow due to their atomic structure; water in this case can promote this process. Thankfully, this did not present a problem in this case, probably because I was using tank (and therefore quite pure) water.

Even after rinsing in fresh (tank) water, there was significant evidence of the flood inside. This pic isn't of corrosion or dust due to age, it's good old Brisbane River mud. Further inside, I found quite a bit of the Brisbane River itself!

Documenation

Documentation is another issue – the more the better. Unfortunately for specialised gear such as this (and even more so as it is ex-military), there's very little (read: no!) information freely available on the Internet. Thank-

Once again, I was surprised at the lack of "damage" when I opened the lid after the big rinse. But delving down revealed a liberal coating of dirt and, in some cases, captured areas of water. All of these required thorough cleaning/drying and testing before there was even a thought of re-applying power.

fully the original owner could give me an electronic copy of the operation manual which did have a short section on troubleshooting. This included a few steps on narrowing down any issues and outlined supply voltages etc.

A logical order

Two days later I finally had the time to take the next step and strip one of these units. After some thought, I decided on the following procedure:

- Strip each board, removing covers, RF shielding, etc.
- Wash each part in a tub of water with a toothbrush/paintbrush/rag.
- Rinse in rainwater.
- Spray liberally with methylated spirits (metho).
- Gently blow excess fluid off with compressed air.
- Suitably label the dismantled components.
- Leave in the hot Queensland sun to dry (we were actually getting some by that stage!)

The methylated spirits act as a dewatering agent, actively excluding moisture from hard to get at areas. I did think about using liberal amounts of WD40 or such but as I wasn't sure of its effect on RF gear, it was only used on some of the connectors.

I also avoided the use of a high pressure washer – this can do more harm than good by destroying fine parts and pushing contaminants into inaccessible places. Gentle water flow is best.

The tools I used (apart from screwdrivers, pliers etc) included a digital camera and notebook to aid reconstruction, an electrical safety tester and multimeter.

Last in, first out: the receiver at the top of the pile was duly removed from the water onto our outdoor table. I started to remove the panels and was surprised at how little mud and residue was inside.

The basic construction consists of a chassis/motherboard, front and rear panels, transformer, DC-DC power supply – these units can run from both AC (100-240VAC/50-440Hz) and DC (10-32VDC) – and ten shielded boards that slot into the motherboard with multiple coaxial cable connections between boards and to the rear panel.

Take copious notes and pics!

For complex equipment it is important to spend the time taking notes, photographs and maybe a little reverse engineering for diagrams. This will aid the reconstruction.

A block diagram or rough circuit will help you understand the operation when it comes time to power on and you have the inevitable faults.

Back to the job at hand: each of the boards had a shield front and back, with some having more push-on tin shielding inside.

It turned out that this level of shielding is ideal for water containment! This emphasises the effort and importance of stripping equipment to its lowest possible level.

RF/IF boards required careful attention to remove dirt and contaminants, without the movement of numerous air wound coils. Removing the brown mud residue was important; it seemed to dry well, with little electrical conduction properties.

But leaving this is fraught with danger: the problem with silt-like residue is that it readily absorbs moisture in high humidity. This could easily be a problem in the future with it becoming conductive and/or corrosive.

The boards themselves seemed to have a protective coating – again this helped in the restoration. Any socketed chips were carefully removed and cleaned, as were their sockets.

While most modern components are impervious to methylated spirits, one problem with using it was that it attacked the dyes on the coaxial cable labels. It did not remove them completely but it is worth keeping this in mind when you spray it around – as the commercial cleaners say, test on a small area first.

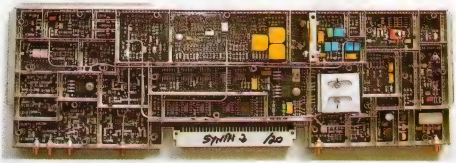
The other point to note is that methylated spirits is extremely flammable and due care must be taken when using it, especially from a spray-bottle.

The power supply

The DC-DC switch-mode power supply PCB was removed from its covers and given the same treatment as the boards.

The mains transformer was more difficult. It was a toroidal type which on first look seemed to be sealed. But on close inspection I could see internal droplets of condensation on the clear wrapping. I just had to let it bake in the hot sun and hope for the best.

Other devices that could trap water, such as trimpots, switches and connec-



A little daunting, perhaps – but if approached in a logical order, disassembly, cleaning and reassembly should achieve the desired result. It's important to handle the cleaning gently, especially when it comes to things like coils and trimmers.

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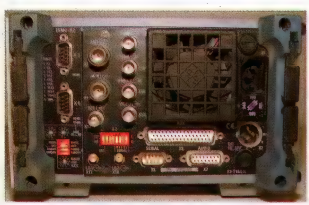

Even if I do say so myself, the clean-up and restoration job has come up a treat. The receivers probably look a darned-sight better than when they were taken out of service. Of course, there's been a little bit of "elbow grease" between then and now!

tors could only be dried with the rest of the board and "hope for the best".

Sunbaking in Queensland

So there we had it. What seemed like a thousand screws later the whole unit was reduced to its component parts, cleaned and placed on a tarp in the sun, baking.

After a full day of sun, the parts were covered, left overnight, then around mid-morning the following day, the unit was re-assembled while each part was still hot from the sun. The power transformer had lost its droplets of moisture, the power switch was no longer weeping when pressed – not a sign of moisture anywhere. Fingers (and everything else!) crossed . . .

By this stage I had done two units and it had taken most of two days – you have to be keen! The next step I took was to unplug the rear fan from the power supply and connect it to my bench supply.

Each of the fans was connected to an independent supply and run. Both were fine, no unusual noise, they sounded just like, well, electric fans. I decided to let the fans run for another two days, drawing air through the units and hopefully removing any further moisture.

Then came the electrical safety tests. As with any piece of electrical equipment, mains insulation needs to be intact (greater than 1MΩ at a test voltage of 500V).

Using a multimeter may give the same resistance reading but only with an applied voltage of a few volts. It is important to test with an electrical safety tester for this reason – the insulation needs to stand up to 500V without breaking down.

Obviously, low voltage equipment doesn't have this requirement.

To do a safety test, make sure the power switch is on and all AC mains circuits are connected and then simply short active and neutral of the mains plug and measuring between there and ground.

Unit 1 was fine but unit 2 was measuring only a few thousand ohms! This turned out to be the heatshrink covering over the power switch connections trapping dirt and moisture. Removing the heatshrink and a spray of WD40 fixed that.

Applying power came next. All boards were popped from their sockets, so the DC supply was only connected to the motherboard.

Initially I tested the unit from DC using a 12V car battery. The DC supply burst into life and all voltages were correct – so far, so good.

Next the AC – I connected it to the mains and powered up – again fine. Plugging in all the boards, reconnecting the coaxial cables and the backup battery went without a hitch as well. Soon there was static coming from the speaker. It's alive!

This receiver is controlled via software through either a GPIB or RS-232 port. Using a terminal program, I was able to initiate the self test routines. Everything passed except for the Synthesiser 2 board, which got a fail.

After pulling the board out again I closely inspected what I initially assumed to be some sort of tuned, solid aluminium RF block. In fact it turned out to be a heat-transfer mechanism from a hidden SOIC socketed chip to the shield cover. Removing the block and chip, then giving it and the socket a good clean fixed this.

Unit number one was now fully operational, I could tune into the local ABC AM radio station down at 612kHz all the way up to the 468MHz emergency services.

As far as the operational specifications, such as selectivity etc, are concerned – I do not know as I don't have the facilities to test this. All I know is that it works and works well, even when compared to my little Yaesu scanner.

These results really show how well built these units are. Their military equipment application says they have to be – and they are made to some of the most demanding and robust construction standards.

I don't think I'd have the same success rate with such a complicated piece of electronic equipment out of a consumer factory in China (not that it might stop me trying!).

Honestly, there were only three areas of iron rust stains – two screws (the rest were stainless steel), the captive screw blocks on the rear "D" connectors and the end of one feed line cable.

There was some white residue on PCBs, probably an oxide of tin or lead from the solder.

So if you do come across flooded gear and you think it's worth having a go – do it!

Just remember the safety of you and others when you attempt this. For 240V applications, always make sure the equipment passes electrical safety tests before plugging it in. SC

And here's the "icing on the cake" – the label might say "fully functional" but it certainly wasn't when removed from the floodwater. Here it is passing the software test routines. Yay!

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dick smith
Talk to the Techxperts

This gutsy little speed controller has a wide range of applications and is simple to build and use. There are no software settings to fiddle with but it does have some really useful features such as low-battery protection, soft start and adjustable pulse frequency. It can run from 12V or 24V batteries at currents up to 20A.

By JOHN CLARKE

20A 12/24V DC Motor Speed Controller Mk.2

Upgraded version of our very popular speed controller

THE MOTOR SPEED Controller described in the June 1997 issue of SILICON CHIP has to be one of the most popular projects we have presented; many thousands have been built. But as popular as it's been, readers have often requested simple modifications to suit myriad applications. So we have come up with a revised design which should cope with virtually every possible variation that readers are likely to envisage. That's a brave statement but it is based on literally hundreds of emails and letters we have answered on the original project in the 14 years since it was published.

The original design is still OK but we strongly recommend this new version since it has more capabilities and is easier to build and connect. In fact, if you have an unassembled version of the old kit, we suggest you toss the old PCB and buy the new PCB plus a few extra bits to make up the new design; it will be worth it.

New features

First, the new PCB has provision for an on-board speed control trimpot (VR1) or as most builders seem to want, an off-board potentiometer.

For ease of wiring, we have added heavy-duty screw terminals to the PCB for the power supply and motor connections. As well, the in-line fuse and fast recovery power diode are now mounted on the PCB and the power Mosfets and power diode have small heatsinks fitted.

The circuit now provides full range speed control from zero to full power; the older design did not allow full speed. Apart from letting the motor operate at full power it also eliminates switching noise caused by the controller (at the full speed setting).

Variable pulse frequency is another new feature. Because the speed controller works by pulse width modulation, with the pulse width varying the voltage fed to the motor, this can produce more noise from the motor. This is due to magnetostriction of the core laminations and rattling of the

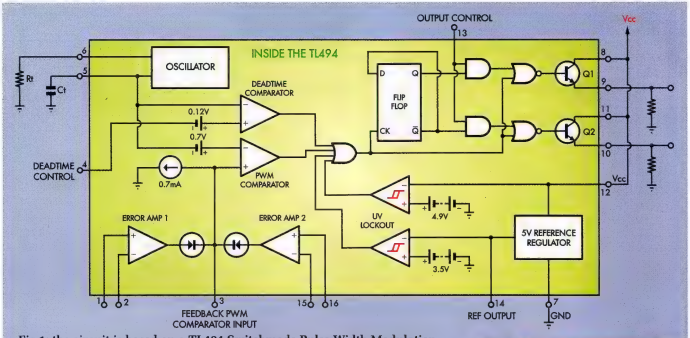


Fig.1: the circuit is based on a TL494 Switchmode Pulse Width Modulation (PWM) Control IC. External timing components R_T & C_T on pins 5 & 6 set the PWM frequency, while output transistors Q1 & Q2 can be configured for either push-pull or single-ended operation.

armature windings. You can often reduce this lamination noise by changing the pulse frequency and there is a trimpot (VR3) on the PCB to provide this feature.

As mentioned above, we have also provided low-battery protection. This is mainly to prevent damage when the circuit is powered from 12V sealed lead-acid (SLA) batteries which will fail completely if they are discharged below 11V.

Soft start is also included. This will bring the motor smoothly up to speed each time power is connected to the circuit, regardless of the speed setting. If soft start is not required, it can be disabled by removing a jumper link.

What's not in the new version? The answer is speed regulation. That is where the circuit reacts to an increase in load on the motor by increasing the pulse width, thereby better maintaining the preset speed. The June 1997 version of this circuit did have a form of speed regulation in that there was feedback from the negative side of the motor to one of the error amplifiers. However, since it did not monitor the motor's back-EMF by itself, it could not really provide full speed regulation. Nor could it provide full speed operation which this latest version does.

The new 12-24V DC Motor Speed Controller is presented as a bare PCB. This can be mounted within an existing enclosure using the four mounting holes with stand-offs and screws. Alternatively, the PCB can be clipped into a standard UB3 plastic case measuring 130 x 68 x 44mm.

Pulse width modulation

The circuit for the 12-24V DC Motor Speed Controller is based on a TL494 Switchmode Pulse Width Modulation (PWM) Control IC. Its block diagram is shown in Fig.1.

An internal sawtooth oscillator sets the PWM frequency, as determined by external timing components R_T and C_T. The oscillator frequency is fed to two comparators (dead-time and PWM) and the resulting PWM signal gated through a 4-input OR gate to a flipflop and thence to the steering control logic for transistors Q1 & Q2.

Q1 & Q2 can be configured to provide push-pull or a single-ended output, as set by the output control input (pin 13). Our circuit ties pin 13

Main Features

- 20A current rating
- 12V or 24V operation
- On-board trimpot or external potentiometer for speed adjustment
- Optional soft start
- 0-100% speed control range
- Efficient PWM control
- PWM frequency adjustment
- Low battery protection

Specifications

Supply Voltage	12-30VDC
Supply Current	20A maximum
Output Current	20A maximum
Standby Current	20mA
Control Range	0-100%
Low Voltage Cut-out	typically set for 11.5V (for 12V battery) or 23V for a 24V battery
Pulse Frequency Adjustment	~100Hz to 1.1kHz (129Hz to 1.28kHz measured on prototype)
Soft Start	from 0-100% (or to set speed) over about 1s
Mosfet gate rise and fall times	1.5µs & 1.6µs respectively

Parts List

1 PCB, code 11106111, 106 x 60mm
1 UB3 plastic box, 130 x 68 x 44mm (optional)
1 4-way PC-mount screw terminal block with barriers (9.5mm spacing) (Jaycar HM-3162 or equivalent) (CON1)
1 3-way screw terminal block with 5.08mm pin spacing (CON2)
3 TO-220 tapped, finned heatsinks, 16 x 22 x 16mm (Jaycar HH-8516)
2 3AG PC-mount fuse clips
1 20A 3AG fast-blow fuse (F1)
1 DIP16 IC socket (optional)
1 TO-220 silicone insulating washer and insulating bush
2 M4 x 15mm screws
2 M4 nuts
4 M3 x 10mm screws
4 M3 x 6mm screws (optional)
1 M3 nut
1 6mm M3 tapped standoffs (optional)
1 2-way pin header for LK1 (2.54mm pin spacing)
1 jumper shunt (LK1)
5 PC stakes (TP1-TP5)

Semiconductors

1 TL494N Switchmode Pulse Width Modulation Control Circuit (IC1)
1 LM2940CT-12 12V low dropout regulator (REG1)
2 IRF1405 55V 169A N-Channel Mosfets (Q1,Q2)
1 BC327 PNP transistor (Q3)
1 2N5484 or 2N5485 N-channel JFET (Q4)
1 MBR20100CT dual 10A 100V Schottky diode (D1)
5 1N4148 switching diodes (D2-D6)
2 15V 1W zener diodes (1N4744) (ZD1,ZD2)

Capacitors

1 22μF 16V low-ESR PC electrolytic
4 10μF 16V PC electrolytic
1 1μF monolithic ceramic
1 470nF MKT polyester
3 100nF 63V or 100V MKT polyester (one required across motor terminals)
1 56nF MKT polyester

Trimpots

1 10kΩ miniature horizontal-mount trimpot or 1 10kΩ linear potentiometer (VR1)
1 10kΩ top-adjust multi-turn trimpot (3296W style) (VR2)
2 100kΩ top adjust multi-turn trimpots (3296W style) (VR3,VR4)

Resistors (0.25W, 1%)

3 100kΩ	1 1kΩ
2 10kΩ	2 47Ω
2 2.2kΩ	

Resistors for testing

1 1kΩ 0.5W resistor (for 12V supply) or 1 2.2kΩ 0.5W resistor (for 24V supply)

low to select single-ended operation, with Q1 & Q2 driven together up to a possible 100% duty cycle, ie, full on.

Dead-time normally refers to push-pull operation and is the time between Q1 switching off and Q2 turning on. But we are not using push-pull operation in this circuit so the only time it comes into play is when the "soft start" feature is enabled. In this case, the dead-time comparator increases the PWM duty cycle as the voltage to the dead-time input, pin 4, slowly drops in voltage after power is applied.

The TL494 includes a 5V reference regulator and we use it here as a bias source for the two error amplifiers. Error amplifier 1 is used for the speed control function while error amplifier 2 is used for the low-voltage cut-out function.

The outputs of the two error amplifiers are ORed together by internal diodes and the commoned output used to control the PWM comparator as well as being made available at pin 3.

Two under-voltage (UV) lock-out Schmitt trigger comparators monitor the reference regulator output and the supply voltage. These comparators switch off the PWM output when the reference regulator drops below about 3.5V (eg, if it is shorted) or if the supply voltage drops below 4.9V. But just to confuse the issue, we don't use these comparators for the low-battery protection; instead, we use error amplifier 2, as mentioned above.

Circuit details

The full circuit of the DC Motor Speed Controller is shown in Fig.2. The motor speed is adjusted using on-board trimpot VR1 or an external potentiometer connected to CON2. This varies the voltage applied to the IN1+ input (pin 1) of internal error amplifier 1 in the TL494. This is configured as a unity-gain amplifier to buffer the input voltage from the speed-control pot.

Trimpot VR2 is connected in series with VR1 to adjust the voltage range for VR1. With VR2 adjusted correctly, the full rotation of VR1 will give the full speed control from 0-100% PWM duty cycle. In this case, 100% duty cycle means that the output Mosfets are fully turned on and so there is no pulse width modulation; the motor is fed with smooth DC.

As already noted, pin 13 of IC1 is tied low for single-ended operation. The collectors (C1 & C2) of the internal transistors are tied together to the Vcc supply while the common emitters (E1 & E2) at pins 9 & 10 are tied to ground via a 2.2kΩ resistor. When the internal transistors are switched on, the gates of Mosfets Q1 & Q2 are driven high via diode D2 and their 47Ω gate resistors.

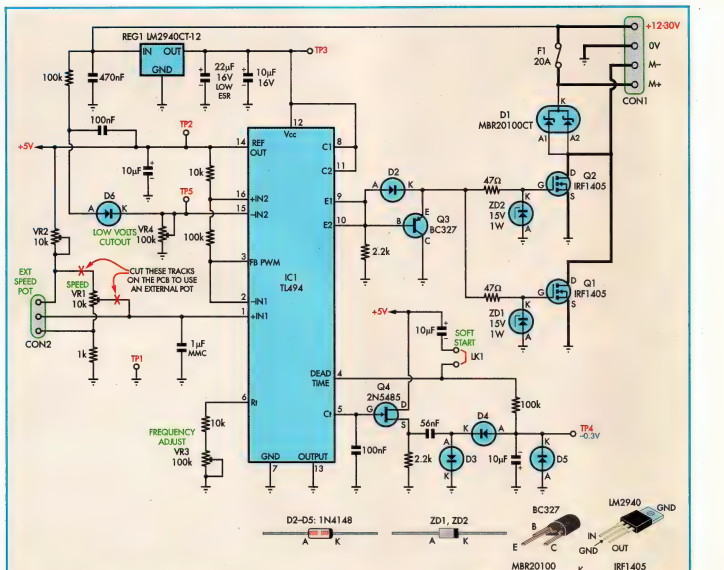
15V zener diodes ZD1 & ZD2 protect the gates from positive transient voltages above 15V and also from voltages below ground (clamped to -0.7V)

When the internal transistors are switched off, the 2.2kΩ resistor on pin 10 pulls the base of transistor Q3 low and this in turn discharges the gate capacitances of Q1 & Q2 to rapidly switch them off, within less than 2μs.

The drains of Mosfets Q1 & Q2 connect to the M- motor terminal and they act as a "low side" switch, pulling one side of the motor low while the other side of the motor connects to the full supply voltage. Fast recovery diode D1 clamps the transient spike voltages generated each time the Mosfets switch off to about 0.7V above the battery supply.

Soft start

As noted above, the dead-time control input is pin 4. Normally this pin should be at 0V so that the PWM duty cycle is set by trimpot VR1 or the external potentiometer at CON2. However, when power is first applied to the circuit, a 10μF capacitor con-



SC 12-24V 20A DC MOTOR CONTROLLER

Fig.2: the complete circuit for the 12-24V DC Motor Controller. IC1 is configured for single-ended operation and its common emitter outputs at pins 9 & 10 drive parallel Mosfets Q1 & Q2 via diode D2 and their 47Ω gate resistors. Q3 ensures that the Mosfets switch off quickly when the internal transistors switch off.

nected between the 5V reference and pin 4, initially holds pin 4 at +5V. This voltage gradually drops to 0V as the capacitor charges via the 100kΩ charge resistor.

While ever the voltage at pin 4 is above about +2.8V, it sets the duty cycle at 0%, ie, no voltage is applied to the motor. As the voltage falls below 2.8V, the duty cycle progressively ramps up to that set by VR1.

The maximum duty available when the dead-time input is at 0V is about 92%. This restriction in duty cycle is absolutely necessary when the TL494 is used in the push-pull configuration, where the output transistors are switched on and off alternately. However, we are using this circuit in single-ended mode and we don't need it; we want to be able to provide a 100% duty cycle, ie, full on.

The restriction in duty cycle to 92% is set by a 0.12V offset applied to the dead-time comparator input from pin 4. This is shown on Fig.1.

To negate the effect of this 120mV offset, we need to generate a small negative voltage to cancel it. This is something the chip designers probably never envisaged but we have come up with a devious scheme.

It involves feeding the sawtooth oscillator signal at pin 5 to the gate of junction FET (JFET) Q4 which is connected as a source follower. It is used to drive a diode pump consisting of diodes D3 & D4, together with the 56nF and 10µF capacitors. Diode D5 prevents the negative voltage going beyond about -0.3V.

The reason it clamps to -0.3V rather than the typical -0.6-0.7V is due to the very low current flow through D5. This negative voltage is then fed to pin 4 via a 100kΩ resistor and this cancels the 120mV offset. Is that sneaky or not?

Pulse frequency variation

As mentioned earlier, we have made provision to vary the PWM switch-

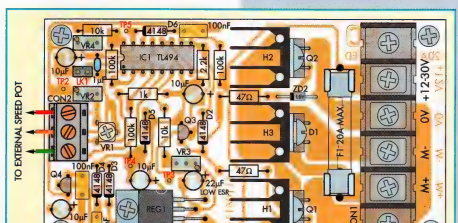


Fig.3: follow this layout diagram to install the parts on the PCB but leave VR1 out if you are using an external speed control pot. Note that diode D1 (but not Q1 or Q2) must be insulated from its heatsink – see Fig.4.

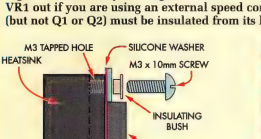
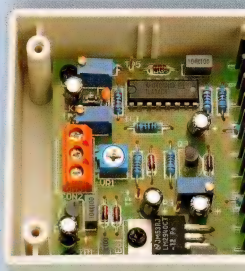


Fig.4 (above): this mounting arrangement shows how diode D1 is insulated from its heatsink using an insulating bush and silicone washer.

Fig.5 (right): cut the tracks indicated here if you install trimpot VR1 but later decided to use an external speed control pot (see text).



ing frequency because it allows you to use a setting which produces the minimum "singing" noise from the motor laminations.

Hence, the oscillator frequency is set by varying the resistance from pin 6 to the 0V line using 100kΩ multi-turn trimpot VR3. This provides a frequency range of adjustment between about 120Hz and 1.2kHz.

Although the input voltage can be anywhere from 12-30V or a little more, to cope with 12V or 24V lead acid batteries, the TL494 is run from a 12V low-dropout regulator REG1 (LM2940CT-12). This can provide a 12V output with an input voltage that is only 0.5V above 12V. As the input voltage drops below this, the regulator's output will also drop in value but the circuit will continue to function until the supply drops below the preset low-voltage cut-out which we will come to in a moment.

REG1 can cope with supply voltage spikes up to 45V which is important if the circuit is run from a 24V battery; in a vehicle, this can range up above 29V and motor spikes will add to that. The IN2- input, pin 15, which monitors the battery voltage is connected via a 100kΩ resistor and is protected by diode D6, so reverse voltage will cause no problems there.

For the rest of the circuit, if the battery supply is reverse connected, heavy current will flow through the integral diodes within Q1 & Q2, via forward biased diode D1 and fuse F1 which will blow and prevent any damage.

Low-battery protection

We already mentioned that error amplifier 2 provides this function and the low voltage setting is provided by trimpot VR4. You can monitor the voltage setting at test point TP5. The set-up procedure is described later in this article.

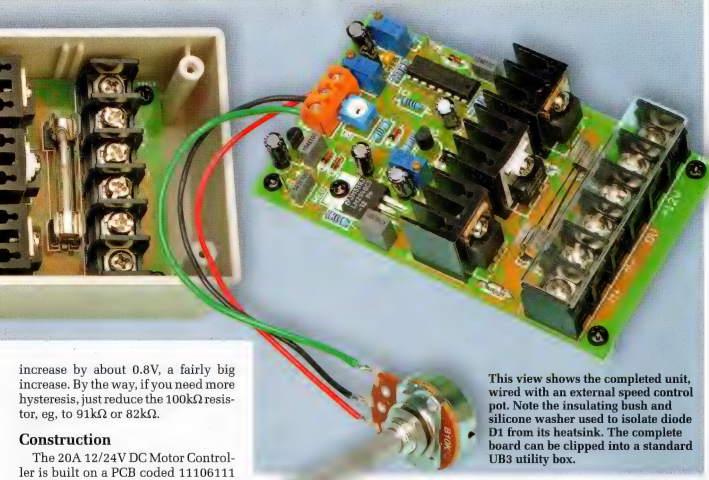
However, there is a little more to the story because we can't simply have the circuit cutting off when the battery voltage drops below 11.5V (for a 12V lead-acid battery). What would happen is that when the circuit stops operating, the battery voltage will inevitably bounce back up again because the current drain suddenly drops. So if the battery voltage goes back up, the circuit starts operating again and then it goes off again and so on. The result is that the motor will get rapid bursts of power as it stutters on an off; not good.

We get around that problem by adding hysteresis to the low-voltage cut-out function.

So instead of simply biasing the +IN2 input, pin 16, from the +5V output at pin 14, we also connect it to the PWM input at pin 3 via a 100kΩ resistor.

Now when the speed controller is working normally, the voltage at pin 3 will vary between 2.5V at 0% duty cycle and 0.7V for 100% duty cycle and this causes the voltage at the IN2+ input to vary between +4.61V and +4.77V. However, when a low-battery condition is detected, the PWM comparator output at pin 3 is forced high to nearly +5V and this means that the +IN2 input at pin 16 is now very close to +5V (instead of between +4.61V and +4.77V).

Hence, for normal operation to resume, the -IN2 input at pin 15 must rise above +5V and that effectively means that the battery voltage has to



This view shows the completed unit, wired with an external speed control pot. Note the insulating bush and silicone washer used to isolate diode D1 from its heatsink. The complete board can be clipped into a standard UB3 utility box.

increase by about 0.8V, a fairly big increase. By the way, if you need more hysteresis, just reduce the 100kΩ resistor, eg, to 91kΩ or 82kΩ.

Construction

The 20A 12/24V DC Motor Controller is built on a PCB coded 11106111 and measuring 106 x 60mm. Fig.3 shows the assembly details.

Begin by checking the PC board for breaks in the tracks or shorts between tracks and pads. That done, check that the hole sizes are correct by test fitting the larger parts (fuse clips, screw terminal blocks, Mosfets Q1 & Q2, etc). The four corner holes should each be drilled to 3mm.

Start the assembly by installing the resistors, followed by diodes D2-D6 and zener diodes ZD1 & ZD2. Table 1 shows the resistor colour codes but you should also check each resistor using a digital multimeter (DMM) before installing it. Take care with the diodes and zener diodes – they must be orientated exactly as shown on Fig.3.

Once these parts are in place, install a socket for IC1. Alternatively, this IC (TL494) can be soldered directly to the board. Make sure it is orientated correctly. The capacitors can then go in and again the electrolytic types must be oriented correctly.

Follow with the trimpots but leave trimpot VR1 out if you intend using an external potentiometer for speed adjustment. Trimpots VR2-VR4 are all multi-turn types and should be orientated as shown. **Note that VR2 is a 10kΩ unit while VR3 & VR4 are both 100kΩ trimpots. Don't mix them up.**

The 3-way screw terminal block is next on the list. Make sure it is correctly seated against the board and that its openings face outwards before soldering its pins. The 4-way terminal strip can then go in. It's secured to the board at either end using two M4 x 15mm screws and M4 nuts. Tighten the mounting screws firmly before soldering its leads to the PCB.

The two fuse clips are next. Note that these must both be orientated with their end stops towards the outside. If you get them the wrong way around, you will not be able to install the fuse afterwards.

Don't be tempted to solder the fuse clips with the fuse in place. If you do, the heat may partially melt the solder used to secure the fuse wire to the end

Table 2: Capacitor Codes

Value	μF Value	IEC Code	EIA Code
1μF	1μF	1u0	105
470nF	0.47μF	470n	474
100nF	0.1μF	100n	104
56nF	0.056μF	56n	563

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	2	47Ω	yellow violet black brown	yellow violet black gold brown

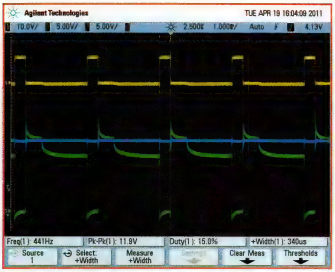


Fig.5: this scope grab shows the controller's operation at a low setting, ie, a duty cycle of 15%. The top (yellow) trace is the signal applied to the gate of Mosfet Q1 and has an amplitude of 11.9V. Each positive gate pulse turns on the Mosfets and pulls the motor's M- terminal low, as shown by the green trace. The blue trace shows the battery voltage at the motor's M+ terminal. Each time the gate voltage drops to zero (ie, at the end of each positive gate pulse), the Mosfets turn off and the motor voltage rises to a spike above the blue (battery voltage) trace. Schottky diode D1 stops it rising a great deal higher.

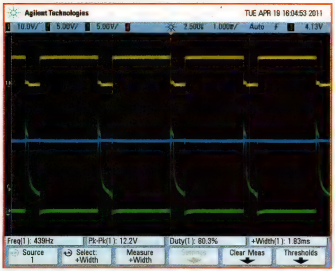


Fig.6: this scope grab shows the operation at a much higher setting, with a duty cycle of 80.3%. In this case, the positive gate pulses (yellow trace) are much longer, at 1.83ms. Now, each time the Mosfets turn off, they generate an even higher spike voltage.

caps and you could get an open circuit or dry joint. Hint: you can use sticky tape to hold the fuse clips (and other parts) in place while you solder them.

Follow by installing PC stakes at test points TP1-TP5 and the 2-way header for LK1. A shorting jumper can then be fitted to this header to enable the soft start feature.

Installing the semiconductors

Transistors Q3 (BC327) and Q4 (2N5485) can now be fitted, followed by regulator REG1 which is mounted horizontally on the board. The latter is installed by first bending its leads down at right angles so that they pass through their mounting holes. REG1's tab is then secured to the PCB using an M3 x 6mm machine screw and nut, after which the leads are soldered.

Don't solder REG1's leads before securing its tab. If you do, you could crack the board tracks as the mounting screw is tightened down.

Mosfets Q1 & Q2 and Schottky diode D1 are each mounted vertically and fastened to separate small heatsinks. The three heatsinks are installed first, by soldering their locating pins to the relevant PCB pads. Make sure that the heatsinks are properly seated against the PCB before soldering them in place.

That done, slide Q1 & Q2 into their mounting holes and fasten them directly to their respective heatsinks using M3 x 10mm machine screws (the heatsinks come pre-tapped). Tighten the screws firmly, then solder their leads.

Diode D1 is mounted in a similar way except that it requires an insulating bush and silicone washer to insulate its tab from the heatsink. Fig.4 shows how this is done. As before, tighten the screw firmly before soldering its leads.

Finally, use your multimeter to confirm that D1's metal tab is indeed isolated from its heatsink (and from the metal tabs of Q1 & Q2).

Testing

Before moving on to the test procedure, note that a 100nF MKT capacitor should be connected directly across the motor's terminals. This is necessary to reduce electromagnetic radiation from the motor.

If you are using an external 10kΩ potentiometer for the speed control, connect this up now. Conversely, if you are using trimpot VR1 instead, this should be installed on the PCB. If you do install VR1 but later decide that you want to use an external pot, then you must cut the PCB tracks running to the top of the this trimpot and to its wiper. This is necessary to prevent the trimpot and the external potentiometer acting in parallel

Fig.5 shows which tracks to cut. These tracks have been deliberately thinned at the indicated locations and can be cut using a sharp hobby knife. If necessary, they can later be rejoined using solder bridges (ie, if you want to revert to using the trimpot). Alternatively, you can leave the tracks intact and remove the trimpot instead.

The completed unit can now be tested by following this step-by-step procedure (without the motor connected):

(1) Connect a 1kΩ 0.5W resistor between the M+ and M- terminals and apply 12-15V DC to the supply terminals (ie, to the +12-30V and 0V terminals). Watch the polarity.

Note that a 24V DC supply can also be used but in that case, you should connect a 2.2kΩ 0.5W resistor between the M+ and M- terminals.

(2) Connect a digital multimeter (set to volts) between test points TP1 (ground, bottom left) and TP3 (above REG1). This lets you check the regulator voltage. You should get a reading on TP3 of somewhere between 11.4V and 12.6V, provided the supply voltage is above 13.6V. TP3's voltage may be slightly lower if the supply voltage is less than 13.6V.

If TP3's voltage is below the expected range, check for incorrectly oriented components (eg, IC1 and the electrolytic capacitors) and for short circuits between tracks.

(3) Check that the reference voltage on TP2 is between

4.75V and 5.25V. If not, check for a short circuit from pin 14 of IC1 to 0V.

(4) Assuming all is correct, adjust VR1 (or the external pot) fully anti-clockwise and check the voltage on the centre terminal of CON2. Adjust trimpot VR2 so that this voltage is the same as that previously measured at TP2 (ie, between 4.75V and 5.25V).

(5) Check that the "dead-time" offset voltage between TP4 & TP1 is at about -0.3V. If this is a positive voltage, check the value of the 100kΩ resistor at D5's cathode and that D3-D5 are orientated correctly. The 10μF capacitors across D5 and on pin 4 of IC1 should also be checked for correct polarity.

(6) Adjust VR4 so that the voltage between TP5 & TP1 is above the TP2 voltage (if this is not done, the PWM drive will not operate due to low-voltage detection).

(7) Connect a DMM set to read DC volts across the M+ and M- terminals. Adjust the speed control pot (or trimpot VR1) and check that the output voltage varies accordingly. With the speed pot fully anticlockwise, the measured voltage between M+ and M- should be 0V. As the pot is wound clockwise, this voltage should rise. The maximum level should be very close to the supply voltage.

Control range

At this stage in the adjustment procedure, the voltage between M+ and M- should reach its minimum well before the speed control pot is wound fully anticlockwise. You now need to readjust VR2 to broaden this range.

To make this adjustment, wind the speed control pot fully anticlockwise and adjust VR2 clockwise so that the voltage between M+ and M- just starts to rise above 0V. That done, slowly adjust trimpot VR2 back anticlockwise until 0V is reached, then back it off slightly further by about a half turn.

Low-voltage cut-out

Trimpot VR4 sets the low-voltage cut-out. To set this at 11.5V, first measure the battery supply voltage and subtract 0.6V from this measurement. That done, multiply the result by 0.426, then adjust VR4 so that the voltage on TP5 measures this calculated value.

For example, if the battery voltage is 12V, then (12 - 0.6) x 0.426 = 4.86V. VR4 is therefore adjusted to give a reading of 4.86V at TP5. When the battery voltage drops to 11.5V, TP5's voltage will fall to 4.65V and the low-voltage cut-out will activate at close to this voltage (ie, between 4.61V and 4.77V). The battery voltage required for the circuit to switch on again is 12.33V – ie, (5V ÷ 0.426) + 0.6V.

If you have an adjustable power supply, the low-battery cut-out action can be tested. To do this, first set the speed pot to its mid-point, so that there is a voltage between the M+ and M- terminals. Now reduce the supply voltage until the voltage between the M+ and M- terminals suddenly drops to 0V. The supply voltage at which this occurs is the battery cut-out voltage and should be close to 11.5V.

If necessary, adjust VR4 to give a more accurate cut-out voltage.

For a 24V battery, the low-battery cut-out voltage can be set to 23V. In this case, measure the battery supply voltage and subtract 0.6V. Now multiply the result by 0.208 and adjust VR4 so that the voltage at TP5 equals the calculated value.

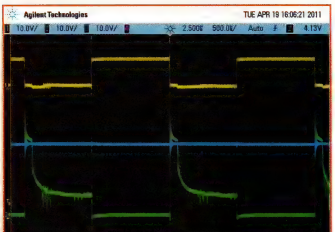


Fig.7: this shows an intermediate speed setting, with a duty cycle of 53.7% and a gate pulse width of 1.225ms. Note that when the Mosfets turn off, the M- voltage briefly rises above the battery voltage (M+). It then falls to a plateau value which represents the motor's back-EMF. Note that there is also some hash on this waveform and this is due to brush and commutator hash.

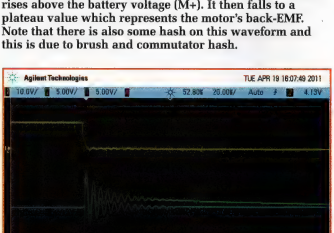


Fig.8: this scope shot illustrates the clamping action of the fast recovery diode (D1). Taken at a much faster scope horizontal sweep speed, it clearly shows the diode action. Note that there is quite a lot of ringing on both the battery supply line (M+ blue trace) and the M- line (green trace). So even with the ringing, the diode faithfully clamps the M- line just above the M+ line. It actually appears to clamp at about 1V above the supply line but the real value is less than 1V.

That completes the adjustment procedure and you can remove the resistor that's across the M+ and M- terminals.

Tweaking the PWM frequency

As stated, the motor may generate an audible noise due to the Mosfets switching on and off at the PWM frequency. VR3 can be adjusted to minimise this noise, although it may not be possible to completely silence it. A 100nF MKT polyester capacitor connected directly across the motor terminals can also help reduce motor noise (and reduce electromagnetic interference). SC

Make high-quality audio recordings with this . . .

USB Stereo Recording & Playback Interface

It uses balanced mikes and has S/PDIF & line inputs as well

By JIM ROWE

Now you can use your laptop PC to make high-quality stereo audio recordings with professional standard balanced microphones. This interface unit lets you make recordings at sampling rates up to 48 kilosamples/second and provides high-quality stereo analog line outputs for playback or monitoring. There's also an S/PDIF digital audio input for recording and an S/PDIF digital audio output for playback.

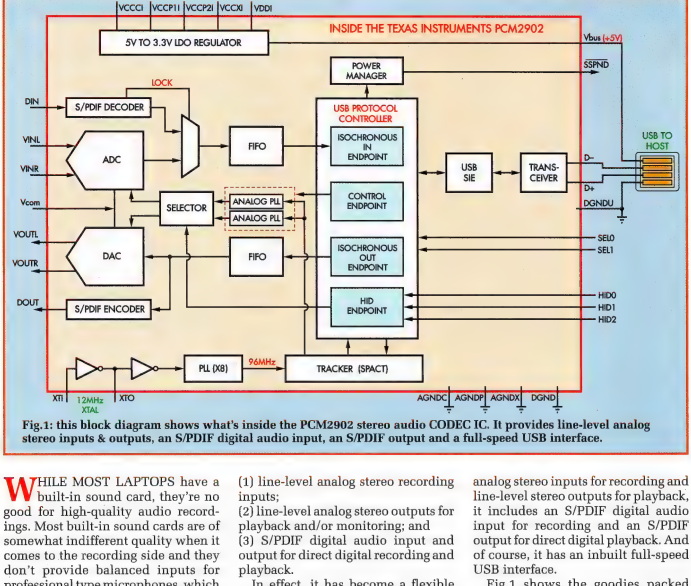


Fig.1: this block diagram shows what's inside the PCM2902 stereo audio CODEC IC. It provides line-level analog stereo inputs & outputs, an S/PDIF digital audio input, an S/PDIF output and a full-speed USB interface.

WHILE MOST LAPTOPS have a built-in sound card, they're no good for high-quality audio recordings. Most built-in sound cards are of somewhat indifferent quality when it comes to the recording side and they don't provide balanced inputs for professional type microphones, which are really necessary for making high-quality recordings.

Hence, if you want to use a laptop, you need an "audio front-end" with balanced-input microphone preamps feeding a pair of high-quality analog-to-digital converters or "ADCs". And since most laptops have at least one USB port, the easiest way to connect such an audio front-end to them is via a USB cable. This has the added advantage of allowing the audio front-end to draw its power from the laptop, via the same cable.

So that was the rationale behind the low-cost audio front-end unit we're describing here. Or at least, those were our basic goals when we started its development. Along the way it "grew some" when we realised that it wouldn't be too difficult to provide it with various bonus features:

(1) line-level analog stereo recording inputs;
(2) line-level analog stereo outputs for playback and/or monitoring; and
(3) S/PDIF digital audio input and output for direct digital recording and playback.

In effect, it has become a flexible multi-purpose USB audio interface – not just for laptops but for virtually any PC. It's easy to build and much lower in cost than comparable commercial units. What's more, there's no software to install – you just connect it up and it runs on Windows XP SP3, Windows Vista and Windows 7 (both 32 & 64-bit). It should also work with recent Linux and Mac operating systems.

What's inside?

The heart of the project is the PCM2902 from Texas Instruments. This was originally developed by Burr-Brown, which was acquired by TI not long ago. The PCM2902 is described as a single-chip stereo audio CODEC with an inbuilt full-speed USB protocol controller, SIE (serial interface engine) and transceiver.

As well as providing line-level analog stereo inputs for recording and line-level stereo outputs for playback, it includes an S/PDIF digital audio input for recording and an S/PDIF output for direct digital playback. And of course, it has an inbuilt full-speed USB interface.

Fig.1 shows the goodies packed inside the PCM2902. To the right of centre is the USB protocol controller block which provides four main USB "end-points": (1) a control end-point which receives control commands from the PC host; (2) an HID (human interface device) end-point which allows inputs to the chip to generate keypress events on the host PC, to control muting, volume, etc; (3) an isochronous IN end-point which handles the transfer of audio recording data from the ADC section IN to the PC via the USB; and (4) an isochronous OUT endpoint which handles the transfer of audio playback data OUT of the PC via the USB, feeding it to the DAC section.

Don't worry too much about these terms but you might like to know that "isochronous" means that the audio data packets are transferred at a con-

What The Acronyms Mean

ADC: an analog-to-digital converter, which samples incoming analog (audio) at a designated rate such as 44,100 samples per second and outputs the samples as a digital serial bitstream. A stereo ADC samples both channels simultaneously but interleaves the samples in the output bitstream (ie, L-R-L-R and so on).

CODEC: short for "coder/decoder" – basically a combination of one or more ADCs with one or more DACs. It can also include functional blocks for encoding and decoding the digital samples.

DAC: a digital-to-analog converter, which converts digital data samples into the equivalent analog voltages or currents. A stereo audio DAC is really two separate DACs, one of which converts the left channel samples in the incoming bitstream, while the other DAC converts the right channel samples.

FIFO: a First-In-First-Out buffer, which provides temporary storage for a stream of digital data. Although it functions like a serial delay line, most FIFOs are actually implemented with dual-ported random-access RAM.

LDO: a Low-DropOut voltage regulator – ie, one which requires a very small difference between the unregulated input voltage and the regulated output voltage in order to operate correctly.

PLL: a Phase-Locked Loop, which is a functional block designed to lock an oscillator to an exact multiple or sub-multiple of a frequency from another oscillator.

SIE: short for "Serial Interface Engine". A functional block which manages the packaging/transmission and reception/unpackaging of data transferred via a serial interface like USB.

S/PDIF: the Sony/Philips Digital Interface Format, a protocol and physical layer specification used to transport digital audio signals between devices and components. The signals can travel over either a coaxial cable or an optical fibre cable (in the latter case it is usually called "TOSLINK"). It is a consumer-level adaptation of the original AES/EBU (Audio Engineering Society/European Broadcasting Union) standard for professional digital audio. The serial audio data stream is encoded with "biphase mark coding".

TOSLINK: short for Toshiba Optical Serial Link, the version of S/PDIF which uses optical fibre cables to carry the digital audio bitstream.

USB: short for "Universal Serial Bus", the serial data communications bus now very widely used to link PCs with a broad range of peripheral devices. The original USB 1.0/1.1 standard supported communication at Low Speed (1.5Mbits/second) and Full Speed (12Mb/s). When USB 2.0 was subsequently introduced this also covered High Speed (480Mb/s), while the recently adopted USB 3.0 standard adds Super Speed (5Gb/s). USB 1.1 and 2.0 use a standard 4-wire cable, with different connectors at each end – Type A for connection to the "downstream" port of the PC or an intermediate hub, and Type B for connection to the "upstream" port of the USB peripheral device.

stant rate (isochronous = equal time). You might also want to note that we're not actually making use of the HID end-point in this project.

To the right of the USB protocol controller block are the USB SIE and transceiver sections which transmit and receive all the data and control packets transferred over the USB signal lines. Just above the protocol controller is the power manager block which controls the power taken by the external circuitry, as directed by the host PC's USB driver.

Thus, when the PC directs the PCM2902 protocol controller to switch the device into low power "suspend" mode because no activity has been detected for a few milliseconds, the power manager block drops the logic level on the SSPND-bar output pin. This is used by external control circuitry to turn off power to everything but the "brains" of the PCM2902 chip itself.

As soon as the PC directs the protocol controller to resume normal operation, the power manager pulls the SSPND-bar line high again, so power is restored to the external circuitry and it can get back to work.

The sections to the left of the USB protocol controller block in Fig.1 are those involved in processing the record and replay signals. In the upper area, there's the stereo ADC section for converting incoming analog audio into 16-bit digital samples, together with the S/PDIF digital audio input decoder. The digital bitstream from one of these is fed through a FIFO (first in, first out) buffer to the isochronous IN endpoint of the USB protocol controller, for transmission to the PC host.

By the way, if there's a signal from the S/PDIF input decoder it becomes the recording signal but if there is no S/PDIF signal, the bitstream from the ADCs is fed to the FIFO block as the recording signal.

In the lower area of the block diagram there's a second FIFO buffer which is fed from the protocol controller's isochronous OUT endpoint with audio playback data received from the PC host. The output of this second FIFO is fed to the stereo DAC section to be converted into analog playback audio. At the same time, it is fed to the S/PDIF encoder section to produce a digital playback bitstream.

So the playback signals simultaneously appear at both the analog audio outputs and the digital S/PDIF output.

Note that the clock signals used by all parts of the PCM2902 are derived from a single 12MHz oscillator inside the chip itself (apart from the crystal and some minor components). An internal PLL (phase-locked loop) is used to multiply the crystal frequency by eight, producing a 96MHz clock that's used to drive most of the chip's circuitry – including the ADCs, DACs and USB control circuitry.

An important feature of the PCM2902 is the "tracker" section you can see just below the USB protocol controller. This takes the 96MHz internal clock and locks it to an audio clock signal derived from the USB data packets, using what TI calls its "SpAct" architecture. This is claimed to reduce clock jitter for both recording and playback and also allows simultaneous recording and playback at different sampling rates.

Note that the PCM2902's ADCs use 16-bit delta-sigma conversion and can work at any of seven standard sam-

pling rates: 8, 11.025, 16, 22.05, 32, 44.1 and 48kHz. The DACs also use 16-bit delta-sigma architecture but can only operate at the three most popular sampling rates: 32, 44.1 or 48kHz.

As you can see then, the PCM2902 is a very powerful chip, containing all the main functions needed for a high-quality USB stereo recording and playback interface.

Specifications

Purpose: a digital stereo recording and playback interface for laptop PCs, which links to the PC via a standard USB cable and is powered from the PC's USB port via the same cable. Features include:

- Twin balanced-input microphone preamps for use with professional type microphones.
- Selectable line-level stereo analog inputs.
- High-quality stereo ADCs for recording at any of seven standard sampling rates (8, 11.025, 16, 22.05, 32, 44.1 and 48kHz).
- Built in stereo DACs for replay at any of three standard sampling rates (32, 44.1 and 48kHz).
- An S/PDIF digital audio input to allow recording directly from an S/PDIF digital audio signal, as an alternative to the analog audio inputs.
- An S/PDIF digital audio output to allow playback via a high-quality digital sound system, as an alternative to the analog audio outputs.
- 16-bit delta/sigma ADCs and DACs.
- Fully compliant with the USB 1.1 specification.
- Installs automatically on Windows XP SP3 and later operating systems (plus recent Mac & Linux systems) using the standard USBaudio.sys drivers – no custom drivers required.
- Fully compatible with Windows-based audio recording and playback software such as "Audacity".
- Frequency response: Recording = 20Hz - 17kHz +0dB/-1.0dB, 15Hz - 20kHz +0dB/-2.0dB; Playback = 30Hz - 18kHz +0dB/-1.0dB, 20Hz - 21kHz +0dB/-2.0dB
- Low current drain (below 70mA).

Circuit description

Refer now to Fig.2 for the complete circuit of the USB Stereo Recorder & Playback Interface. Now that you've seen inside the wondrous PCM2902 chip, you should be able to follow its operation without any problems.

All the circuitry to the left of the PCM2902 itself (IC3) is concerned with preparing the incoming audio signals for recording. The left-channel analog recording circuitry is shown at top, with identical circuitry for the right channel below it. Each channel has a balanced microphone input connector (CON1 & CON3) and each of these feeds a balanced-input mic preamp using three sections of an MCP6024 low-noise, low-voltage CMOS quad op amp (IC1c,b&d and IC2c,b&a).

The gain of these preamps is adjusted via a dual-gang potentiometer (VR1a & VR1b). This allows the gain to be optimised without running into overload. The maximum preamp gain is 201, which should be sufficient for most microphones.

The line-level output from each mic preamp (ie, at pin 14 of IC1d & pin 1 of IC2a) is fed to its corresponding position on double-pole switch S1. Alternatively, the second position of each pole is used to select the signals from the line-level input sockets (CON2 and CON4). The signals selected by S1a and S1b are then fed to third-order active low-pass filters based on IC1a & IC2d.

These fare used for "anti-aliasing" and filter out any audio components above about 22kHz. Without these filters, there could be audible alias components being generated as part of the sampling process.

The outputs of the anti-aliasing filters are in turn fed to the ADC inputs of the PCM2902 (VinL at pin 12 and VinR at pin 13) via 1µF coupling capacitors.

Note that because the op amps in IC1 and IC2 are being operated from a single DC supply rail (Vcc) of approximately 4.0V, they must be biased midway between Vcc and 0V to ensure maximum output swing with minimum distortion. This Vcc/2 bias voltage is derived from a resistive voltage divider consisting of two 2.7kΩ resistors (just above IC1a). The same voltage is also used to bias the replay filters and output buffers in IC4, which we'll come to in a moment.

The only remaining part of the recording circuitry is CON5. This is the S/PDIF digital bitstream input. Its signal is simply fed into the Din input (pin 24) of the PCM2902 via a 100nF capacitor.

Replay circuit

The replay circuitry is shown to the lower right of the PCM2902. The DAC output signals appear at VoutL (pin 16) and VoutR (pin 15) of the PCM2902 and are fed via 1µF coupling capacitors to active low-pass filters based on IC4b and IC4c. These two filters are identical to those used in the recording channels and remove any glitches that are present in the DAC outputs. The filtered signals are then passed through unity gain buffer stages IC4a and IC4d and fed to the line output connectors (CON7 & CON8) via 1µF capacitors.

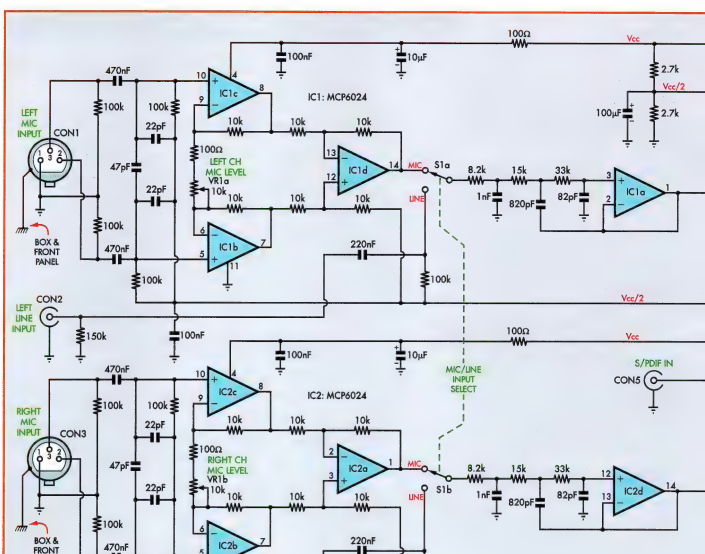
The S/PDIF digital replay output appears at the Dout pin (pin 25) of the PCM2902. This is then fed to the S/PDIF output connector (CON6) via a 150nF capacitor and a resistive divider to provide the correct peak-to-peak amplitude.

The external components needed by the PCM2902's 12MHz master clock oscillator are shown just below the Dout output pin. Apart from the 12MHz crystal itself, there are two low-value NPO ceramic capacitors which are used to bring the crystal's frequency into the correct range (12.000MHz ±6kHz), plus a 1MΩ biasing resistor to ensure that the oscillator has minimum "start-up" delay when power is applied.

USB interface

The only part of the circuit we haven't yet discussed is the USB interface and power management section. Because the SIE and USB transceiver are inside the PCM2902, the external part of the USB interface is really very simple. As shown, the four pins of USB connector CON9 are connected to the corresponding pins on the PCM2902, via 22Ω suppressor resistors in the case of the D+ and D- signal lines and via a 2.2Ω current-limiting resistor in the case of the Vbus line.

The +5V supply applied to pin 3 (Vbus) when the interface is connected to the PC host (via a USB cable) is passed through an LDO (low dropout) regulator inside the PCM2902. The



USB STEREO RECORDING & PLAYBACK INTERFACE

Fig.2: the circuit for the USB Stereo Recording & Playback Interface. Quad op amps IC1 & IC2 form balanced microphone preamp and filter stages, while IC4(a)-4(d) filter and buffer the line outputs from IC3. In addition, IC3 directly interfaces to the S/PDIF input & output sockets and to a type-B USB socket.

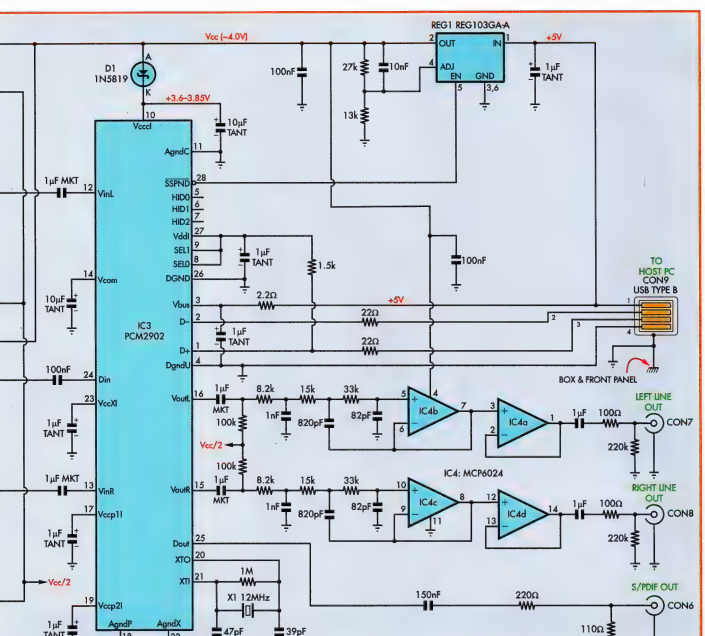
LDO's output in turn appears at pin 27 (Vddi). Because the D+ signal line of the USB interface is connected to this pin via a 1.5kΩ resistor, this means that the D+ signal line is pulled up to a voltage close to Vbus. According to the USB specification, this is the correct way of indicating to the PC host controller that a USB device is capable of full-speed (12Mb/s) operation.

Finally, we come to the power management circuitry which is based on REG1, a REG103GA-A LDO regulator made by TI. There are two features that make this regulator special.

The first is that its output voltage can be adjusted, something that's not all that common with LDOs. The second is that it's provided with an enable input (pin 5), so its output can be turned on and off very quickly by a control signal applied to this pin.

These two features, together with its use of internal DMOS circuitry to achieve an exceptionally low drop-out voltage (typically <20mV for 90mA output current) make the REG103GA-A ideally suited for this sort of application.

REG1's output voltage is set to 4V by the resistive divider connected to pin 4 (ADJ). In addition, pin 5 (EN) of REG1 is connected to pin 28 (SSPND-bar) of



the PCM2902. So whether or not REG1 provides this output voltage depends not only on the presence of +5V from the PC via pin 1 of CON9 but also on the logic level of the SSPND-bar control signal derived from the power management circuitry inside IC3.

If the PC directs the USB protocol controller inside IC3 to reduce the USB device's power level and enter "suspend" mode, the power management circuitry inside IC3 pulls pin 28 down to 0V. This in turn pulls the EN pin of REG1 low and switches off the Vcc output voltage. As a result, IC1, IC2 & IC4 all shut down, as does the circuitry inside IC3 which gets its power from the Vcc line via diode D1 and pin 10 (Vccci).

When the PC directs the USB protocol controller inside IC3 to resume normal operation, its power management circuitry pulls pin 28 high again. REG1 then switches its output voltage (Vcc) back on again, thus restoring normal operation.

At this stage, you may be wondering how the protocol controller, SIE, USB transceiver and master clock oscillator inside IC3 are able to respond to any directions from the PC after it has entered suspend mode (ie, when REG1 has turned off the power). The secret

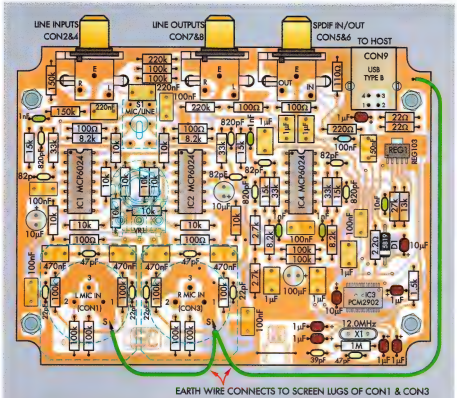


Fig.3: follow this diagram to install the parts on the PCB, starting with REG1 & IC3. The parts with blue outlines mount on the case lid and are connected via wire extension leads. Note that you can substitute 1µF monolithic ceramic capacitors for the 1µF tantalums shown on the overlay.

here is that these sections inside the PCM2902 are all powered from the internal LDO which is fed with the +5V applied to its Vbus pin (pin 3) from pin 1 of CON9.

This voltage is available all the time, as long as the device is connected to a PC host via a USB cable. Hence these sections inside the PCM2902 are always able to respond to commands from the PC.

The rest of the circuitry inside IC3 (eg, the ADCs and DACs) is powered from the Vcc line via D1 and the Vccci pin. As a result, it's only these sections inside IC3 which "go to sleep" in suspend mode. Since these are the parts of the PCM2902 which draw the most current, they need to be shut down when the device enters suspend mode.

The result of this power management system is that the total current drawn by the USB Stereo Recording & Playback Interface in suspend mode is less than 220µA; much lower than the 60-70mA drawn in operating mode. This means that it comfortably meets the appropriate USB specification – that all USB devices must be capable of entering a suspend mode, where they must draw no more than 2.5mA from the USB power line.

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
470nF	0.47µF	470n	474
220nF	0.22µF	220n	224
150nF	0.15µF	150n	154
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
1nF	0.001µF	1n	102
820pF	NA	820p	821
82pF	NA	82p	82
47pF	NA	47p	47
39pF	NA	39p	39
22pF	NA	22p	22

Building it

All parts except for switch S1, po-

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	2	220kΩ	red red yellow brown	red red black orange brown
❑	2	150kΩ	brown green yellow brown	brown green black orange brown
❑	12	100kΩ	brown black yellow brown	brown black black orange brown
❑	4	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	27kΩ	red violet orange brown	red violet black red brown
❑	4	15kΩ	brown green orange brown	brown green black red brown
❑	1	13kΩ	brown orange orange brown	brown orange black red brown
❑	12	10kΩ	brown black orange brown	brown black black red brown
❑	4	8.2kΩ	grey red red brown	grey red black brown brown
❑	2	2.7kΩ	red violet red brown	red violet black brown brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	110Ω	brown brown brown brown	brown brown black black brown
❑	6	100Ω	brown black brown brown	brown black black black brown
❑	2	22Ω	red red black brown	red red black gold brown
❑	1	2.2Ω	red red gold brown	red red black silver brown

This view shows the completed PCB. Note that it must be secured to the case lid before soldering the leads from the switch, potentiometer & XLR sockets (see text).

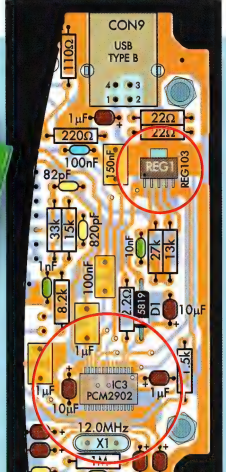


Fig.4: this enlarged section of the PCB shows the mounting details for REG1 & IC3. Use a fine-tipped iron to solder their pins (see text).

tentiometer VR1 (microphone gain) and the two XLR mic input sockets (CON1 & CON3) are mounted on a double-sided PCB coded 07106111. This is housed in a standard diecast aluminium box measuring 119 x 94 x 57mm.

Fig.3 shows the parts layout on the PCB. Begin by checking the board for any defects (especially around IC3 & REG1), then test fit the RCA sockets to make sure their mounting holes are the correct sizes. Check also that the corner cut-outs have been made.

Once that's done, start the assembly by installing the two SMDs (IC3 & REG1). IC3 (PCM2902) comes in an SSOP-28 package, while REG1 comes in a 5-pin SOT223 package. As shown in Figs.3 & 4, both devices are mounted on the top of the board.

It's important to use a soldering iron with a very fine tip to install these two devices. You also need some fine-gauge resin-cored solder and some solder wick. A magnifying lamp or magnifying glass will also be handy.

REG1's pins are more widely spaced than IC3, so install it first. Start by carefully positioning the device accurately over the pads on the board, then lightly tack solder one of its outside pins. Adjust its position if necessary, then solder the remaining pins. **Note that you also have to solder its heatsink tab (opposite the pins) to the matching rectangular pad on the PCB.**

IC3 is a bit trickier to install but the procedure is similar. Make sure it is orientated correctly, with the dimple in the "pin 1" corner at upper right, then lightly "clamp" it into place using a pair of self-closing tweezers. Check that it is accurately positioned, then place a tiny drop of solder on the tip of your iron and just touch the tip to the end of pin 1, so that the solder flows down and "tacks" the pin to the PCB pad.

Now do the same for pin 15 which is diagonally opposite, at the lower left corner of the device. These two "tacked" pins will now hold the device in place while you solder the remaining pins. Use a minimum of solder for each pin but don't worry if you make a few inadvertent solder bridges between the tracks or adjacent pins.

Once you've soldered all 28 pins, use a magnifying glass to check for solder bridges. If you do find any, they are quite easy to remove using a narrow strip (ie, 2mm wide) of desoldering braid or solder wick.

The trick is to place the braid directly over the bridged pins (or tracks), then press the braid firmly down onto the pins using the tip of your iron for a couple of seconds. The braid then not only heats up the pins but also "sucks up" and removes the solder bridge as well.

In practice, you'll find that this is much easier to do than it sounds, especially if the PCB has a solder mask.

Once you've finished, check all the pins again with a magnifying glass, just to make sure. It will be harder to remove any remaining problems later when the adjacent parts are in place.

The "through-hole" parts can now be installed on the PCB starting with the single wire link and the resistors. Check each resistor using a digital multimeter before soldering it into place on the PCB, then fit diode D1

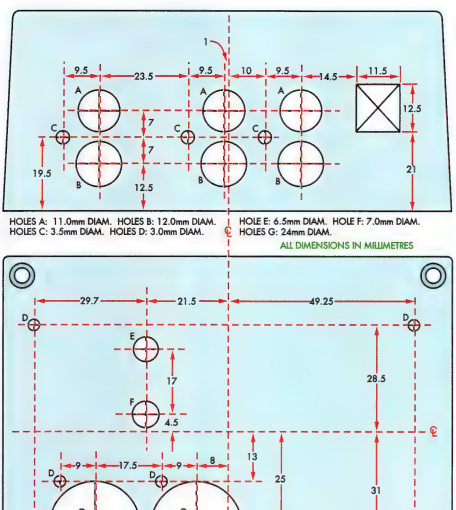


Fig.5: this is the drilling template for the case. Start each hole with a small pilot drill to ensure accuracy and use a tapered reamer to enlarge the holes for the RCA sockets (A & B). The two holes for the XLR sockets (G) can be made by drilling a series of small holes around the inside diameters, knocking out the centre pieces and filing for a smooth finish.

(watch its orientation) and the 14-pin DIL sockets for IC1, IC2 & IC4.

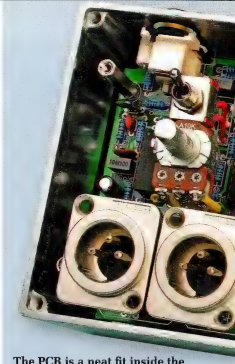
Follow with the low-value ceramic and MKT capacitors, then install the electrolytic and tantalum capacitors. The electrolytics and tantalums are all polarised, so be sure to fit them with correct orientation as shown on Fig.3.

Note that both the circuit and overlay depict the use of six 1µF tantalum capacitors. Alternatively, you can substitute 1µF monolithic ceramic capacitors (see parts list).

The 12MHz crystal (X1) is next on the list and this goes in just below IC3. **It should be fitted with a thin insulating washer underneath it, so that its metal case cannot make contact with any of the nearby copper tracks on the top of the board** (it's a good idea to fit this even if the PCB has a solder mask). This insulating washer can be made from a small rectangle of clear plastic film, with two small holes punched in it 5mm apart to allow X1's pins to pass through.

Alternatively, you can mount the crystal so that its case is slightly proud of the PCB.

The PCB assembly can now be completed by plugging in the three ICs and fitting the three double-RCA sockets and the USB type B socket. Make sure that the ICs are correctly orientated.



The PCB is a neat fit inside the case. In practice though, it's first attached to the lid before the entire assembly is dropped into place.

Drilling the case

If you build this project from a kit, the box and its lid may be supplied pre-drilled and the lid may also come with a screen-printed front panel. If not, then you'll have to drill and cut the holes in the case yourself.

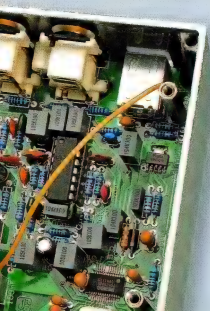
Fig.5 shows the drilling details. Note that holes "B" in the rear panel for the "upper" RCA sockets are 12mm diameter, while holes "A" for the "lower" sockets are 11mm diameter. The reason for this difference is that the larger "B" holes allow easier entry of the lid/PCB assembly into the box, during final assembly.

Having drilled, cut and de-burred all of the holes, the next step is to fit the front panel to give the unit a professional finish. Fig.6 shows the front-panel artwork and you can either copy this or download the panel in PDF format from the SILICON CHIP website and print it out. The panel can then be laminated and attached to the lid using double-sided tape.

Once it's in position, cut out the holes using a sharp hobby knife.

Final assembly

Now for the final assembly. The first step is to fit switch S1, potentiometer VR1 and the two XLR sockets to



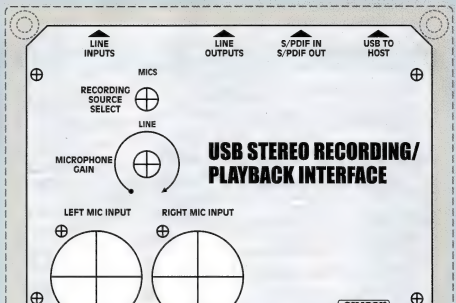


Fig.6: this full-size front panel artwork can be copied or you can download it in PDF format from the SILICON CHIP website and print it out.

the lid assembly. Cut the pot shaft to about 10mm long before fastening it in position.

The switch and pot are secured using the supplied nuts, while the XLR sockets are each held in place using a two M3 x 10mm machine screws, star lockwashers and nuts.

The next step is to fit extension leads to the terminals of both S1 & VR1. These leads are run using 0.7mm tinned copper wire and should be about 25mm long for S1 and about 35mm long for VR1. That done, sleeve the extension wires with either 1.5mm heatshrink tubing or 2mm varnished cambric tubing. The sleeves for the leads from S1 should be about 18mm long, while those for VR1's leads should be about 28mm long.

The three main connection spigots on the rear of XLR sockets CON1 & CON3 are fitted with similar extension leads. These need to be only about 12mm long, as the sockets extend downwards much further than the switch and pot terminals. They also don't need any insulating sleeves, as there will be only about 4mm free above the PCB when it is subsequently mounted on the lid.

Fig.7 shows how the assembly goes together. Before mounting the board in place, you need to fit four 35mm-long spacers to the holes near the corners of the lid. These spacers are

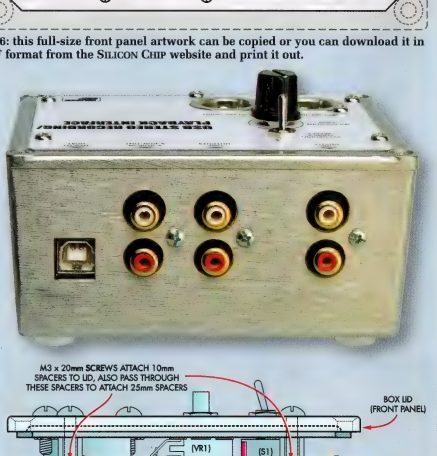


Fig.7: here's how the assembly fits inside the case. Six wire extensions are required for VR1, six for switch S1 and three each for the XLR sockets.

Parts List

1 double-sided PCB, code 07106111, 109 x 84mm
1 diecast metal box, 119 x 94 x 57mm (Jaycar HB-5064)
1 mini DPDT panel-mount toggle switch (S1)
1 10kΩ 16mm dual pot. (VR1)
1 knob to suit
2 XLR balanced male connectors, panel-mount (Jaycar PP-1058, Altronics P 0881)
1 12.000MHz crystal, HC49/4H case (X1)
3 PC-mount dual RCA sockets (Jaycar PS-0280, Altronics P 0212)
1 PC-mount type-B USB socket (Jaycar PS-0920, Altronics P 1304)
3 14-pin DIL IC sockets
4 M3 x 25mm tapped metal spacers
4 M3 x 10mm tapped metal spacers
4 M3 x 20mm machine screws, Phillips head
4 M3 x 10mm machine screws, Phillips head
4 M3 x 6mm machine screws, Phillips head
4 M3 hex nuts
4 M3 star lockwashers
3 4G x 9mm self-tapping screws
1 600mm length of 0.7mm tinned copper wire
1 330mm length of 1.5mm heatshrink tubing
1 200mm length of insulated hook-up wire

Semiconductors

3 MCP6024-I/P quad op amps (IC1, IC2, IC4) (from Microchip Direct)
1 PCM2902 stereo audio CODEC (IC3) (from RS Components)
1 REG103GA-A adjustable voltage regulator (REG1)
1 1N5819 Schottky diode (D1)

Capacitors

1 100µF 16V RB electrolytic
2 10µF 16V RB electrolytic
2 10µF 16V tantalum
6 1µF 25V monolithic ceramic or tantalum
6 1µF MKT polycarbonate
4 470nF MKT polycarbonate
2 220nF MKT polycarbonate
1 150nF MKT polycarbonate
7 100nF MKT polycarbonate
1 10nF MKT or greencap
4 1nF 50V NPO ceramic
4 820pF 50V NPO ceramic
4 82pF 50V NPO ceramic
3 47pF 50V NPO ceramic
1 39pF 50V NPO ceramic
4 22pF 50V NPO ceramic

Resistors (0.25W 1%)

1 1MΩ	4 8.2kΩ
2 220kΩ	2 2.7kΩ
2 150kΩ	1 1.5kΩ
12 100kΩ	1 220Ω
4 33kΩ	1 110Ω
1 27kΩ	6 100Ω
4 15kΩ	2 22Ω
1 13kΩ	1 2.2Ω
12 10kΩ	

made up using M3 x 25mm and M3 x 10mm tapped metal spacers which are stacked together and secured using M3 x 20mm machine screws.

As shown, the screws go through the front panel and initially secure the 10mm spacers in place. The 25mm spacers are then wound on over the protruding ends of the screws.

Once the spacers are in position, you're ready to attach the PCB to the lid. It will be necessary to dress the leads from S1, VR1 and the XLR sockets so that their ends align with their matching holes in the PCB. It also helps if the various leads have their ends trimmed to staggered lengths, so that they can be guided through in sequence.

A pair of long-nose pliers can be used to help guide the leads through their respective holes.

If this proves too awkward, remove S1 and potentiometer VR1 from the lid, then slip their leads down through the PCB. The lid can then be introduced to the PCB, at the same time guiding the six XLR socket leads through their holes. Once it's in position, secure the board using four M3 x 6mm machine screws, then slip the switch and pot back up through their mounting holes and do up their nuts.

Finally, the leads from the XLR sockets, the pot and the switch can be soldered to the PCB pads and trimmed to length.

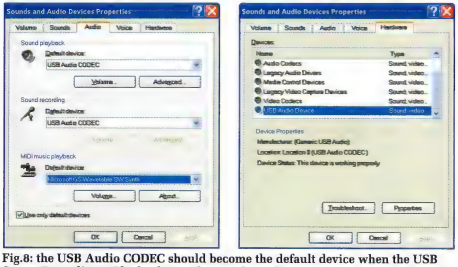


Fig.8: the USB Audio CODEC should become the default device when the USB Stereo Recording & Playback Interface is plugged in (Windows XP dialog boxes).

Earth lead

There's just one more wiring step to complete the front panel/PCB assembly. This is to fit an insulated "earthing" lead which connects from the PCB earth copper to the body/screen lugs of the XLR connectors. This in turn connects the PCB earth to the metal case when it's all later screwed together.

Fig.3 shows how to install this lead. It's run using insulated hook-up wire and is connected to the PCB earth copper just to the right of CON9. It then runs across the board to the screen lug of CON3 and then to the screen lug of CON1.

That done, the PCB/front panel assembly can be completed by fitting

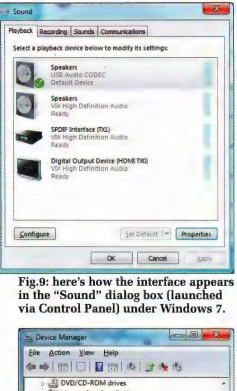


Fig.9: here's how the interface appears in the "Sound" dialog box (launched via Control Panel) under Windows 7.

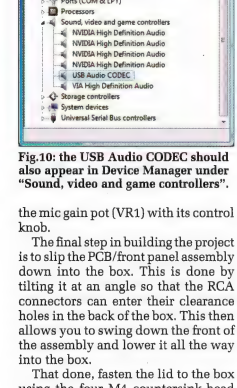


Fig.10: the USB Audio CODEC should also appear in Device Manager under "Sound, video and game controllers".

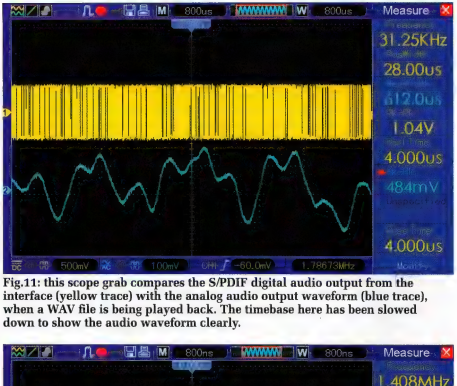


Fig.11: this scope grab compares the S/PDIF digital audio output from the interface (yellow trace) with the analog audio output waveform (blue trace), when a WAV file is being played back. The timebase here has been slowed down to show the audio waveform clearly.

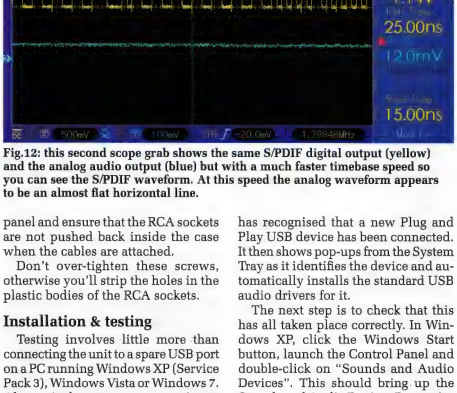


Fig.12: this second scope grab shows the same S/PDIF digital output (yellow) and the analog audio output (blue) but with a much faster timebase speed so you can see the S/PDIF waveform. At this speed the analog waveform appears to be an almost flat horizontal line.

the mic gain pot (VR1) with its control knob.

The final step in building the project is to slip the PCB/front panel assembly down into the box. This is done by tilting it at an angle so that the RCA connectors can enter their clearance holes in the back of the box. This then allows you to swing down the front of the assembly and lower it all the way into the box.

That done, fasten the lid to the box using the four M4 countersink-head screws supplied and use three 4G x 9mm self-tapping screws to secure the three dual RCA sockets to the rear of the case. These self-tapping screws pass through the "C" holes on the rear panel and ensure that the RCA sockets are not pushed back inside the case when the cables are attached.

Don't over-tighten these screws, otherwise you'll strip the holes in the plastic bodies of the RCA sockets.

Installation & testing

Testing involves little more than connecting the unit to a spare USB port on a PC running Windows XP (Service Pack 3), Windows Vista or Windows 7. Alternatively, you can connect it to a spare downstream port on an external USB hub that's connected to the PC.

After a few seconds, you should hear a greeting from the PC's sound system to indicate that the operating system has recognised that a new Plug and Play USB device has been connected. It then shows pop-ups from the System Tray as it identifies the device and automatically installs the standard USB audio drivers for it.

The next step is to check that this has all taken place correctly. In Windows XP, click the Windows Start button, launch the Control Panel and double-click on "Sounds and Audio Devices". This should bring up the Sounds and Audio Devices Properties dialog. If you then click on the "Audio" tab, you should see "USB Audio CODEC" listed in the drop-down device selection lists for both Sound Playback and Sound Recording (Fig.8). This

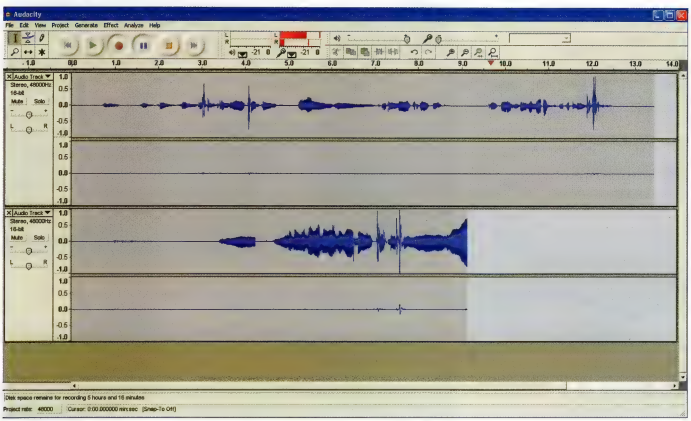


Fig.13: Audacity is an excellent freeware program for recording and editing audio files, with versions available for Windows, Apple Macs and Linux systems (from audacity.sourceforge.net).

should also be the case if you click on the "Voice" tab.

Now click on the "Hardware" tab and select "USB Audio Device". You should see the following information in the Device Properties area:

Manufacturer: (Generic USB Audio)
Location: Location 0 (USB Audio CODEC)
Device Status: This device is working properly.

If you are using Windows 7, launch the Control Panel and double-click on the "Sounds" icon. This brings up the dialog box shown in Fig.9 and you should see that the "USB Audio CODEC" has been installed as the default device.

You can also check the device has been correctly installed in Device Manager. Launch Device Manager from Control Panel, then expand the "Sound, video and game controllers" entry and check that "USB Audio CODEC" is listed – see Fig.10. This applies to both Windows XP and Windows 7 (and Vista).

Using it

Using the unit with your PC for audio recording and playback is straightforward. The first step is to select it as the "Default device" in the drop-down lists under both the Audio and Voice tabs of the Sounds and Audio Devices Properties dialog (Windows XP). You can also use the Volume tab to adjust the replay volume and to get Windows to provide a volume control icon in the system tray at the end of the taskbar.

Your new USB Stereo Recorder & Playback Interface will now be the default device on your PC for both audio recording and playback. And because it's fully compatible with all the standard audio drivers built into Windows XP/SP3 and later operating systems, you'll be able to use it with virtually any of the popular audio recording, editing and playback applications.

Even if you don't have such a suitable application installed on your PC at present, there are quite a few available for free downloading on the web. One I can recommend is Audacity which can be downloaded from the Audacity website at **audacity.sourceforge.net** The current version for Windows XP/SP3 is V1.2.6 but there's also a beta V1.3.13 that's described as "the best version for Windows 7 and Vista". There are also versions for Apple Macs and Linux systems.

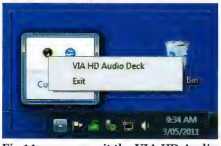


Fig.14: you can exit the VIA HD Audio Deck applet by right-clicking its icon in the System Tray.

Via shutdown error

Finally, note that with this device connected, you may get a shut-down error on machines with Via sound systems which automatically launch the Via Audio HD Deck applet. You can prevent this by closing this applet before shutting down – just right-click the Via HD Audio Deck icon in the System Tray and click "Exit" (Fig.14).

Another option is to prevent the Via HD Audio Deck applet from automatically starting when the PC is booted. That's done by clicking Start, typing in *msconfig*, selecting the Startup tab and clearing the relevant check box. Or you can simply ignore the shut-down error and click OK to close the applet and force a shut-down. SC

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CLEARANCE SALE

4CH DVR KIT WITH 4 CAMERAS

Suited to small surveillance installations in the home or office, this 4 channel DVR can store over 200 hours of video on the internal 320GB HDD. View the recorded video in an indexed event log via a computer or external monitor. Package includes 4 weather resistant IR cameras, 4 x 18m cables, remote control and mains adaptor.

DVR
- 4 x camera inputs
- 1 x composite video output
- MJPEG compression
- SATA hard drive interface
- 320GB Seagate SV35 Surveillance Hard Drive

Camera
- CMOS sensor, 350TV lines
- Inbuilt infrared illumination
- Day/night operation

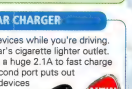
QV-3024 WAS $599.00

$479.00
SAVE $120.00

DUAL USB PORT CAR CHARGER

Charge your Apple® devices while you're driving. Simply plug into the car's cigarette lighter outlet. One USB port outputs a huge 2.1A to fast charge an iPad®, while the second port puts out 1A for charging other devices such as iPhone® etc.

NEW 2011



- Unit includes a USB charging cable to suit iPad® /iPhone®/iPod® MB-3659

$29.95

INDOOR/OUTDOOR SPEAKERS

Versatile speakers that can be mounted to a wall or ceiling and can be rotated 180 degrees for perfect sound projection. Each has a polypropylene woofer and dome tweeter. Ideal for conference rooms, auditoriums, lecture halls or out on the patio.

4" 25WRMS
- Dimensions: 210(H) x 140(W) x 120(D)mm

CS-2475 $69.95

5" 30WRMS
- Dimensions: 245(H) x 185(W) x 168(D)mm

CS-2476 $79.95

6.5" 40WRMS
- Dimensions: 296(H) x 217(W) x 190(D)mm

CS-2477 $99.00

8" 50WRMS
- Dimensions: 345(H) x 285(W) x 220(D)mm

CS-2478 $149.00

NEW 2011

FROM **$69.95**

Sold as a Pair

TURNTABLE WITH BUILT-IN PRE-AMPLIFIER & PC ENCODING

Contemporary design turntable that converts your old vinyl to modern digital WAV, MP3 or OGG format. It has a high quality magnetic cartridge, which ensures clear and distortion free conversion. Equipped with a built in preamp, has a line level RCA output for component or amplifier integration. Features a selectable belt drive system and an auto stop function.

NEW 2011

- Mains powered
- Dimensions: 370(L) x 350(W) x 95(H)mm

GE-4134

$99.00

KIT OF THE MONTH

Universal Power Supply Regulator Kit

Refer: Silicon Chip March 2011

This is an upgraded version of the original universal power supply kit published in August 1988. One small board and a handful of parts will allow you to create either a regulated ±15V rail or +15VDC single voltage from a single winding or centre tap transformer (not included).

NEW 2011

- Includes all PCB & components for board
- Transformer not included
- PCB Dimension: 72(L) x 30(W)mm

KC-5501

$14.95

CASSETTE PLAYER WITH USB/SD ENCODING MUSIC BOX

Digitally encode your old cassette tape collection straight to SD card or memory stick or use as a standard cassette player with its high quality amplified internal speakers. Also allows recording directly from a USB stick to SD card or vice versa. Features a crystal clear AM/FM digital tuner, blue back light LCD, alarm clock with sleep & snooze function.

- Cassette playback and record player
- USB / SD card reader
- Repeat one / all / Program / Random play
- Store up to 40 AM/FM stations
- Built-in amplifier and stereo speakers
- Line in & headphone output
- Requires 2 x AAA batteries
- Dimensions: 250(W) x 204(D) x 85(H)mm

GE-4139

NEW 2011

$99.00

LITHIUM ION CR123A BATTERY & CHARGER

CR123A batteries are commonly used in some LED torches and many cameras. Now there's a rechargeable option with this lithium-ion CR123A battery & matching charger. The intelligent design will fully recharge the included battery in about 3 hours with LED charge status indicator.

- Battery voltage: 3.0VDC (NOTE: will measure 3.7VDC with no load)
- Capacity: 650mAh
- Charge time: 3 hours
- Charger input: 12VDC
- Dimensions: 90(L) x 40(W) x 25(H)mm

MB-3581

NEW 2011

Spare CR123A Li-ion battery to suit:

SB-2411 $13.95

$29.95

7" TFT Colour Monitor with Headrest & DVD Player

If you don't already have a DVD player or other AV source in the car, then install one of these to act as the "master" unit for the in-car video entertainment system. Units will not only play DVDs, but also your video files such as DivX, MPEG4, etc, and even play videos on your USB stick or SD card. You can even use IR wireless headphones or connect up an Xbox360® or Playstation3® via the AV input. Supplied with IR remote control and two games controllers.

- Supports infrared earphones
- In-built games system (CDs supplied)
- Supports USB/MS/MMC/SD card
- Screen dimensions: 7inches
- Resolution: 1440 x 234 (16:9/4:3 selectable)
- Power: 12VDC
- Headrest dimensions: 280(W) x 200(H) x 110(D)mm

QM-3776 WAS $269.00

$229.00
SAVE $40.00

PROBE THERMOMETER

Suitable for lab, chemistry and industrial applications. It measures in Celsius and Fahrenheit and has a stainless steel probe and protective cap. Batteries included.

- Auto power-off
- Low battery indication
- Data hold
- Dimensions: 185(L) x 36(W) x 19(H)mm

QM-7217 WAS $34.95

$24.95
SAVE $10.00

All Savings are based on Original RRP

To order call **1800 022 888** **www.jaycar.com.au**

Prices valid until 23/06/2011. Limited stock on sale items. No rainchecks.

Jaycar Electronics

Tax Time

HIKVISION PTZ SURVEILLANCE

Hikvision Outdoor 22x PTZ Camera

Pans, tilts & zooms at high speeds - capturing sharp images of fast moving objects even in low lighting conditions. Features an impressive range of video settings, including automated camera motion pre-programming that enables up to 104 preset points for the camera to scan through.

- Supports both Hikvision and Pelco-P/D protocols
- 1/4 Sony® SuperHAD CCD
- 752(H) x 582(V) resolution (480 TVL)
- Pans 360°, with speed up to 75°/sec
- Tilts 0° to 90°, with speed up to 50°/sec
- Zooms 22x (3.9-85.8mm)
- Power supply: 24VAC
- Dimensions: 6", 287(L) x 242(Dia)mm

$999.00
SAVE $100.00

Note: Carried in limited quantities in major stores only, call before driving across town.
QC-8602 WAS $1099.00

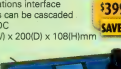
Hikvision 3D PTZ Camera & DVR Control Keyboard

The latest in integrated surveillance management, this state of the art keyboard controls up to 256 Hikvision PTZ cameras (QC-8602) and up to 31 Hikvision DVRs (QV-3044 / QV-3045). Features intuitive 3D joystick for easy and responsive control of PTZ & IP cameras.

- Supports both Hikvision and Pelco-P/D protocols
- Password protection of controlled devices
- RS-485 communications interface
- Up to 16 keyboards can be cascaded
- Input voltage: 12VDC
- Dimensions: 360(W) x 200(D) x 108(H)mm

$399.00
SAVE $100.00

Note: Carried in limited quantities in major stores only, call before driving across town.
QC-8601
WAS $499.00



PROFESSIONAL H.264 DVR RECORDERS

Using the Texas Instruments Davinci DSP and Techwell H.264 codecs, a real-time operating system and combining the most advanced technology, such as video and audio encoding/decoding, hard disk recording and multi-stream networking. Featuring both DVR and digital video server capabilities, you can store or archive to DVD/CD, NFS/SAN or external USB mass storage device. Use either stand-alone or to build a powerful surveillance network. Suitable for banks, telecommunication, transportation, factories, warehouse etc.

Available in two models:

8-Ch Professional H.264 DVR with 500GB HDD
QV-3044 WAS $1,499.00
NOW $1,299.00 SAVE $200.00

FROM $1299.00
SAVE $200.00

16-Ch Professional H.264 DVR with 1TB HDD
QV-3045 WAS $1,999.00
NOW $1,799.00 SAVE $200.00

HANDHELD INSPECTION CAMERAS

Inspection Camera with 2.4" LCD

With a camera diameter of only 9mm, detailed inspection of some very tight spots is possible. Its comfortable grip and forward facing controls make it easy to use. The CMOS colour camera has a 1 metre reach and the 2.4" colour LCD screen is positioned for easy viewing. Requires 4 x AA batteries.

- Adjustable LCD brightness
- Resolution: 480 x 234 pixels
- Attachments: Mirror, hook & pick-up magnet

QC-8710

Also available:
2m Gooseneck Extension Shaft
QC-8702 $99
(suits QC-8710 & QC-8700)

$169.00

Inspection Camera with Detachable Monitor

The Digitech handheld micro inspection camera allows you to perform a detailed visual inspection in hard to reach areas. Its pistol grip design and detachable 2.4GHz monitor make it easy to locate and diagnose the unreachable. Requires 4 x AA Batteries.

Camera:
- Image sensor: CMOS
- Resolution: 704 x 576 pixels
- Dimensions: 186(W) x 41(H) x 145(D)mm (Excluding goosenock)

Monitor:
- LCD Screen Type: 2.5" TFT-LCD
- AV output for recording
- Dimensions: 100(W) x 70(D) x 30(H)mm

QC-8700

$229.00

2.8" TFT LCD MONITOR & AV RECORDER

The smallest and lightest LCD monitor/recorder on the market with a multitude of applications. Monitor CCTV cameras, record audio & video to an SD card or use it as for playback either through the unit or via the AV out to an external monitor or TV. Rechargeable & ultra-portable, complete with AV lead, instruction manual & charger.

- Built-in rechargeable battery
- Dimensions: 88(L) x 58(W) x 17(D)mm

QM-3824 WAS $129.00

$109.00
SAVE $20.00

NETWORK CONNECT VANDAL PROOF MINI DOME CAMERA 2MP

Designed to take advantage of power over Ethernet to reduce installation costs and setup time. This camera connects straight to your existing network for complete control. Access the camera through a web interface by hitting the IP address of the device and logging in. The web interface allows you to control the camera around 3-axis, zoom, adjust visual settings, record, take snapshots and setup scheduled recording.

- Progressive scan CMOS
- Compression H.264/MPEG4/JPEG
- Dimensions: 99(W) x 97(L) x 45(H)mm

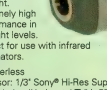
QC-8625 WAS $399.00

$359.00
SAVE $40.00

SAVINGS ON PROFESSIONAL CCD CAMERAS

High Resolution Day / Night Colour CCD

High resolution day/night camera with Sony® sensor, colour by day, black and white by night. Extremely high performance in low light levels. Perfect for use with infrared illuminators.



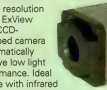
- Flickerless
- Sensor: 1/3" Sony® Hi-Res SuperHAD CCD
- Resolution (Horizontal TVL): 550
- Power requirements: 24VAC/12VDC

QC-8621 WAS $249.00

$199.00
SAVE $50.00

High Resolution ExView Colour CCD

A high resolution Sony® ExView HAD CCD-equipped camera to dramatically improve low light performance. Ideal for use with infrared illuminators and features high speed electronic shutter, back light compensation and 3 stage automatic gain control.



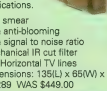
- Sensor resolution (H x V pixels): 752 x 582
- Resolution (Horizontal TVL): 550
- Power: 24VAC/12VDC

QC-8622 WAS $299.00

$229.00
SAVE $70.00

Wide Dynamic Range CCD Camera

This high grade camera is based around the Sony® SS2 vertical double-density wide dynamic range CCD system. It provides a high quality picture in conditions which would render most other cameras useless. See website for complete specifications.



- Low smear
- High anti-blooming
- High signal to noise ratio
- Mechanical IR cut filter
- 470 Horizontal TV lines
- Dimensions: 135(L) x 65(W) x 50(H)mm

QC-3289 WAS $449.00

$399.00
SAVE $50.00

MINI DVR KIT WITH BUTTON-HOLE CAMERA

Capture meetings, conferences or lectures with this high definition video and audio mini DVR kit. Store up to 32GB on an SD card, then allow you to view the video on the 2" TFT LCD screen with different buttonhole options so it's completely covert and discreet. Includes a Li-ion rechargeable battery, charger, AV leads, USB cable and dummy buttons for disguising the camera.

- Approx 10 hours of video
- 128MB flash memory
- Camera resolution: 420TV lines
- Windows XP, Vista, 7 compatible
- Dimensions: DVR: 65(W) x 54(H) x 14(D)mm
  Camera: 22(W) x 34(H) x 15(D)mm

QC-8006 WAS $249.00

$229.00
SAVE $20.00

Tools For The Trade

46W GOOT 240V SOLDERING IRON

High quality Japanese made soldering iron with exceptional heat recovery. The ceramic heater is automatically controlled by the heating load of the tip. With its high insulation and low current leakage, soldering of precision flat ICs and CMOS is safe. The heater on/off control uses a zero-volt switch circuit which reduces noise.

- Tip temperature is set at 320°C
- The power lead is made from flexible silicone rubber
- The handle incorporates a ribbed rubber piece for superior grip
- Electricity Safety Approval Number SAITE20185

TS-1430

$79.95

Spare tips available:

0.5mm Tip (as supplied with iron)	TS-1432 $19.95
0.3mm Tip	TS-1434 $19.95
0.3mm Chisel Tip	TS-1436 $19.95

High Quality Iron

PRO SOUND LEVEL METER WITH CALIBRATOR

Suitable where accuracy, repeatability and validation is required. Ideal for vehicle noise testing, race scrutineering, traffic/aircraft noise or any evidence-based noise testing. Conforms to IEC 61672-1 Class 2 for sound level meters. Calibrator included.

- Backlit LCD
- Analogue outputs
- Dimensions: 278(L) x 76(W) x 50(D)mm

QM-1592

WAS $399.00

$299.00

SAVE $100.00

INDUCTANCE /CAPACITANCE / FREQUENCY DMM

Ideal for audio enthusiasts designing their own crossovers. Features large digits and 30-minute auto power off. Supplied with Carry case and K-type probe with curly cord. See website for full specifications.

- Display: 2000 count
- Transistor Test
- Dimensions: 194(H) x 91(W) x 44(D)mm

QM-1324 WAS $44.95

$39.95

SAVE $5.00

NEW TOOLS FOR THE TRADE

Spot Face Cutter for Strip Boards

Designed to neatly remove copper track on strip type prototyping boards. Insert the tool in the pre-drilled hole and rotate it until the track is removed entirely. Easy to use and efficient.

- Length: 110mm
- Handle measures: 60(L) x 17(W) x 17(D)mm

TD-2461

$8.95

NEW 2011

Stainless Steel Tweezer Set - ESD safe

Set of 3 tweezers, duckbill head, angle fine and straight superfine. ESD coating to reduce static discharge.

- Measures: Angled & duckbill 120mm, superfine 135mm

TH-1760

$19.95

NEW 2011

Spiral Drive Drill/Driver

Spiral driven drill/driver is ideal for very fine work. Push the handle to rotate the collet slowly. Add drill bit or screwdriver bit. Comes with 2 pin vice collects and 3 small drill bits.

- Measures: 180(L) x 15(Dia)mm overall (uncompressed)

TD-2089

$16.95

NEW 2011

2011 Engineering Catalogue Out Now!

Over 500 pages

NEW exciting products

Grab a copy now!

MR16 HALOGEN GLOBES

Low voltage, high brightness halogen lights used as general lighting around the house or shops, automotive and camping use.

Voltage	Angle	Cat no.	Was	Now	Save
12V	30º	SL-2733	$7.45	$2.95	$4.50
12V	38º	SL-2730	$7.45	$2.95	$4.50
12V	12º	SL-2731	$7.45	$2.95	$4.50
12V	38º	SL-2732	$7.45	$2.95	$4.50
24V	38º	SL-2745	$8.95	$2.95	$6.00

BUY BULK AND SAVE

Buy 5 for $10

Save over 50%

F-CONNECTOR TOOL SET

All the tools you need for cutting, stripping and crimping F-connectors for coax cable installations.

Kit includes:

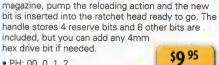
- Coax cable stripper
- Compression crimp tool
- Heavy duty cable cutter
- 10 x F-59 plugs
- Nylon storage case: 152(W) x 220(H) x 45(D)mm

TH-1804 WAS $79.95

$39.95

SAVE $40.00

10-IN-1 ROTARY PUMP-ACTION SCREWDRIVER



This screwdriver has a rotary magazine that stores the bits. When a different bit is required, rotate the magazine, pump the reloading action and the new bit is inserted into the ratchet head ready to go. The handle stores 4 reserve bits and 6 other bits are included, but you can add any 4mm hex drive bit if needed.

- PH: 00, 0, 1, 2
- Slotted: 1.5, 2, 3
- Torx: T5, T6, T8, T10
- Dimensions: 168(L) x 26(Dia)mm

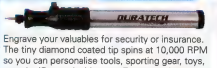
TD-2108

$9.95

DEAL

Buy 2 for $15 SAVE $4.90

MICRO ENGRAVER



Engrave your valuables for security or insurance. The tiny diamond coated tip spins at 10,000 RPM so you can personalise tools, sporting gear, toys, security ID on valuables etc. Engraves glass, ceramics, metals and plastics. Batteries and case included. Tip is replaceable.

- Size: 160(L) x 15(Dia)mm

TD-2468

$19.95

Replacement tip sold separately TD-2469 $6.95

HANDY SERVICE AIDS

Isopropyl Alcohol

Uses as a head cleaner, surface cleaning and prep, contact cleaning, stain removal in the laundry etc. Also a medical-grade surface disinfectant. Dries quickly and is relatively non-toxic. 50% concentration.

A choice of two sizes:

20ml Spray

NA-1062 WAS $2.50

NOW $1.50 SAVE $1.00

200ml Bottle

NA-1064 WAS $6.95

NOW $4.95 SAVE $2.00

FROM $1.50

Super Glue Debonder

Super glue is tenacious in sticking skin together, and has been exploited as an alternative to surgical sutures. Debonder will quickly and painlessly separate skin stuck with super glue.

- 20ml bottle with applicator

NA-1501

$1.95

DEAL

Buy 2 for $3

Heavy-duty PVC Tape

Cordon off hazardous areas or create an unmistakable marker with this heavy duty PVC tape. The vivid colouring will draw anyone's attention to the barrier.

- 33m roll

DEAL

Buy 2 for $15

Two colours available:

Red/White NM-2864

WAS $15.95 NOW $9.95 SAVE $6.00

Yellow/Black NM-2866

WAS $15.95 NOW $9.95 SAVE $6.00

DeoxIT ProGold Contact Cleaner & Rejuvenator - Pen Style

This product will not only clean, but it will help restore your equipment to its original condition, and improve its performance.

NS-1430

$19.95

Also available

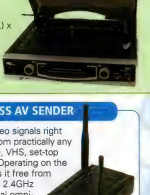
DeoxIT Contact Cleaner & Rejuvenator Aerosol NS-1434 $24.95

DeoxIT Contact Cleaner & Rejuvenator Solution Kit NS-1436 $24.95

MUSIC CENTRES

3 Speed Turntable with Speakers & Audio Output

Listen to vinyl collections directly from the unit and its built-in speakers or use the line level output to listen on an external amplifier. Features a 3.5mm headphone jack for personal listening with adjustable bass control. Great for the family home or apartment.



- 33/45/78 RPM
- Stereo amplifier
- Automatic stop
- 45 RPM adaptor
- Mains powered
- Dimensions: 35(L) x 31(D) x 13(H)mm

GE-4136

$79.00

NEW 2013

Digital CD/USB/SD Encoding Music Box WITH Clock & AM/FM Radio

The music box allows you to record your CD collection straight to SD card or memory stick. Records directly from USB drive to SD card or vice versa. This modern & user friendly design features a crystal clear AM/FM digital tuner, blue back light LCD, alarm clock with sleep & snooze function. Wake up to your choice of radio, buzzer, CD or favourite songs stored on SD card or memory stick. Features battery back up, protects your settings in case of a power failure.

- CD / CD-R, RW / MP3-CD playback
- Repeat one / All / Program / Random play
- Store up to 40 stations
- Built-in amplifier and stereo speakers
- AUX in & Headphone output
- Requires 2 x AAA batteries
- Dimensions: 250(W) x 204(D) x 86(H)mm

GE-4138

$99.00

NEW 2013

USB Cassette Deck with PC Encoder

Record cassette tracks to your computer via USB or play back through the built-in 5W speaker. You can also run the line level outputs to an external amplifier and use it as a component cassette deck.

- Dimensions: 178(L) x 72(H) x 178(W)mm

GE-4054 WAS $79.95

$59.95

SAVE $20.00

5.8GHZ WIRELESS AV SENDER

Send audio and video signals right round the house from practically any video source - DVD, VHS, set-top box, cable TV etc. Operating on the 5.8GHz band keeps it free from interference on the 2.4GHz band and an external omni-directional antenna provides a transmission range of up to 100 metres.

AR-1880

WAS $89.00

$74.00

SAVE $15.00

Extra receiver available AR-1881

WAS $64.95 NOW $39.95 SAVE $25.00

5" SPEAKERS WITH USB

NEW 2013

The built-in amp provides 30WRMS per channel. Input is either via line-level RCA or USB, so it will accept memory sticks or any other USB device. Add an MP3 player for a complete digital music system. It also has bass, treble, volume and MP3 track controls on the back panel. Perfect for your next patio party.

- Mounting brackets included
- Dimensions: 180(W) x 235(H) x 180(D)mm

CS-2437

$199.00

Sold as a Pair

VIDEO/AUDIO CONVERSION DEVICES

Active VGA + Audio to HDMI Converter

This converter box takes the VGA output + stereo audio signal from your PC, and converts them to now common HDMI format whilst maintaining full high-definition resolution. Mains adaptor included.

- Dimensions: 90(L) x 68(W) x 25(H)mm

AC-1609 WAS $129.00

$99.00

SAVE $30.00

Also available:

HDMI to VGA/Component and LR Analogue Audio Converter

AC-1605 WAS $149.00 NOW $129.00 SAVE $20.00

PLASMA/LED/LCD FULL MOTION WALL BRACKET

Provides full motion off the wall. The 620mm extension arm gives a range of rotation of 180° and tilt of -12°, so it is ideal for mounting in the corner of a room, or mounting the TV in an otherwise awkward and unviewable position. Also allows for ±2° lateral roll to ensure the TV is perfectly level after installation.

- Accommodates TVs from 23 to 37" up to 45kg.

CW-2829

$109.00

NEW 2013

OMNI-DIRECTIONAL MAST ANTENNA - 3G CELLULAR

Ideal for enhancing fringe mobile phone reception or 3G Internet performance for a farm or a boat. It provides a very handy 7dBi of gain in any direction. Made from fibreglass and supported by an aluminium support piece and two sturdy clamps.

- Frequency range:- 800/900/1800/1900/2100MHz
- Overall antenna length 1.05m approx.

AR-3313

$99.00

NEW 2013

Digital to Toslink/Coax Audio Converter

Converts digital audio from either coax or Toslink inputs and outputs to Toslink or coax. It has a built-in amplification feature; it can serve as a repeater of audio signals and extend (double) the transmitting distance.

- Dimension: 42(W) x 40(D) x 22(H)mm

AC-1801 WAS $59.95

$49.95

SAVE $10.00

Digital to Analogue Audio Converter

Converts your digital audio from either a coax or optical source to a standard analogue left and right RCA output. Useful for connecting DVD/Blu-Ray players to displays or audio equipment that have a no digital audio input.

- Dimensions: 42(W) x 40.5(D) x 22(H)mm

AC-1603

WAS $69.95

$59.95

SAVE $10.00

Also available:

Analogue to Digital Audio Converter

AC-1611 WAS $79.95 NOW $59.95 SAVE $20.00

COMMUTER SPECIAL

Portable DAB+/FM Radio with Earphones

An ultra-compact DAB+ radio that is small enough to fit in a pocket. Never miss your favourite radio stations while on the go. Provides excellent reception and crystal clear digital sound. Runs on 2 x AAA batteries (not included), it is also equipped with a standard FM radio.

- Earphones included
- Dimensions: 68(L) x 38(W) x 21(H)mm

Note: DAB+ not available in all areas.

AR-1754

$99.00

High Quality Lightweight Stereo Headphones

Ultra-lightweight stereo headphones that provide outstanding performance and comfort. Featuring high output drivers, they produce crystal clear sound with crisp highs and smooth bass response. Soft leatherette swivel ear pads, adjustable headset and 1.2m lead.

AA-2061

$24.95

DEAL

Buy both for $110 Save $13.95

BLACK MAINS EXTENSION LEAD

Perfect for stage, lighting, DJ or other applications where the inconspicuousness of a black extension lead is required. Rated to 10A max.

NEW 2013

2m PS-4152 $5.95

5m PS-4155 $9.95

10m PS-4157 $14.95

MONITOR POWER & SAVE

Wireless 3-Outlet Mains Power Meter

Simply plug an appliance into each sender unit, enter local electricity price and monitor the usage on the LCD receiver unit. Also monitors the cumulative usage via the memory as well as the greenhouse gas emissions.

- Transmission range: 30m
- Receiver requires 3 x AA batteries
- Clock and alarm function
- Dimensions: Sender: 58(W) x 125(H) x 48mm
  Receiver: 100(W) x 130(H) x 36(D)mm

MS-6116 WAS $99.95

$69.95
SAVE $30.00

Remote Controlled 240V Mains Outlets

Switch any mains appliance rated up to 10A on or off remotely. Control up to three separate devices and switch them individually. Includes 3 mains outlets and 1 remote control.

- Transmission range: 30m
- Frequency: 433.92MHz
- Remote size: 100(L) x 35(W) x 20(H)mm

MS-6140
WAS $39.95

$29.95
SAVE $10.00

150W LAPTOP POWER SUPPLY 15-24VDC

Specifically designed for use with laptop computers. Features short circuit and overload protection, an LED power indicator and USB output for charging USB devices. Comes with 9 different DC adaptors that suit most laptop computers on the market.

$119.00

- Input voltage: 100-240VAC 50/60Hz
- 7 Selectable DC voltages
- Dimensions: 63(W) x 180(D) x 40(H)mm

MP-3471

3-STAGE 48V 9A BATTERY CHARGER

Compact and lightweight. Suitable for golf buggies, electric wheelchairs or similar applications. It monitors and manages your charging with three different stages and will maintain the optimum charge level. Cables included.

MASSIVE SAVINGS!!!

- Short circuit, output current, polarity and thermal protection
- LED charge status indication
- Digital Charge Display
- Dimensions: 298(D) x 112(W) x 60(H)mm

MB-3628 WAS $499.00

$399.00
SAVE $100.00

SOLAR RECHARGEABLE LED SPOTLIGHT

Perfect for your car, boat, workshop, camping or fishing trip. It has a dual position swivel handle for maximum versatility and a high tech solar panel so it can be charged at all times.

- 140 Lumens
- Solar cell, car cigarette lighter and mains chargers included
- Detachable weatherproof solar station
- Size approx: 175(L) x 120(W) x 150(H)mm

ST-3312

$39.95
NEW 2011

RECHARGEABLE 35W HID SPOTLIGHT

Ideally suited to search and rescue, boating, professional shooters, security or other high-power applications. Housed in a tough weather-resistant ABS housing with shoulder strap for extended use. The built-in rechargeable battery gives about 50 minutes of continuous use and it recharges either from the mains plugpack or a car cigarette lighter socket.

- Output: 3300 lumens
- Power: 35W
- Dimensions: 300(L) x 210(Dia)mm

ST-3369 WAS $149.00

$129.00
SAVE $20.00

Spare globe available:
ST-3363 WAS $39.95 NOW $29.95 SAVE $10.00

4 WAY POWERBOARD WITH FILTER / SURGE AND OVERLOAD PROTECTION

Guard your expensive HiFi, TV, or VCR etc. against damage. This powerboard offers 4 outlets, all filtered and surge protected. Black in colour.

- 4 Surge and Spike protected mains outlets
- 10 amp resettable overload circuit breaker
- Power on indicator in switch
- Approval Number : N17298
- Cable length: 1 metre

MS-4057

$14.95
NEW 2011

12V 200AH DEEP CYCLE GEL BATTERY

Deep-cycle gel performance for solar installations and other alternative energy systems.

- Capacity: 200Ah (20hr. rate)
- Initial charge current: 30A
- Cycle voltage: 14.4 - 15V
- Standby voltage: 13.5 - 13.8V
- Dimensions: 523(L) x 239(W) x 223(H)mm
- Weight: 62kg

SB-1697

$799.00
NEW 2011

Note: Not stocked in all stores but can be ordered. Call your nearest store for details.

260 LUMEN RECHARGEABLE CREE® LED TORCH

This torch outputs 260 lumens of white light from a battery that is slightly larger than a single AA. Great for every day activities and more demanding uses such as hiking or caving adventures.

$69.95
NEW 2011

- Burn time: 5 hrs
- Includes one rechargeable 3.7V 2200mAh Li-ion battery
- Mains charger included
- Dimensions: 205(H) x 45(W)mm

ST-3453

LED LIGHT LANTERN WITH SOLAR CHARGER PSU ADAPTOR

A super bright white LED lamp with an integrated compass. Can be charged via included mains power, car charger or by the unit's 2.5W solar panel.

- Included 2.5Ah/6V battery
- Lamp measures: 250(H) x108(Dia)mm

ST-3128 WAS $99.95

$59.95
SAVE $40.00

RECREATIONAL SOLAR KITS

Clean renewable energy wherever you go. Convert your 4WD or caravan to generate sufficient power to operate several appliances - 12V camping essentials and luxuries etc. Just add a battery for a self-sustained setup. Two versions to choose from.

80W Standard Package

- 1 x 80W monocrystalline solar panel ZM-9097
- 1 x 12V 6A charge controller MP-3128
- 2 x female PV connector PS-5100
- 2 x male PV connector PP-5102

ZM-9300 WAS $450.00

$425.00
SAVE $25.00

160W Advanced Package

- 2 x 80W monocrystalline solar panel ZM-9097
- 1 x 12V 20A charge controller MP-3126
- 3 x female PV connector PS-5100
- 3 x male PV connector PP-5102
- 1 x solar panel Y-lead 2 socket to 1 plug PS-5110
- 1 x solar panel Y-lead 2 plug to 1 socket PS-5112

ZM-9302 WAS $900.00

$850.00
SAVE $50.00

CREE® XP-G HIGH POWER LED

The XP-G series offers world leading lumen output and efficiency. They can deliver over 150 lumens for cool white, and over 110 lumens for warm white. A fantastic solution to lighting where limited power is available. With a life expectancy of over 50,000 hours, and you have a lighting solution that is truly hard to beat. Lens sold separately.

White	ZD-0445	$17.95
Warm White	ZD-0447	$19.95

NEW 2011

FLEXIBLE STRIP LED LIGHTING

These low voltage (12VDC) LED light strips are perfect for edge-lighting or to illuminate signs, window displays and other small lighting applications. The LEDs are mounted on a flexible printed circuit board with a no-fuss, no mess 3M adhesive backing. The strip is sold cut-to-length in 50mm segments or a continuous length up to 5m. Each 50mm segment has 3 LEDs and requires 12VDC@16mA. Various colours available.

$3.95 Per segment

- Sold cut-to-length in 50mm segments
- 3 LEDs per segment
- 3 LED segment dimensions: 50(L) x 8(W) x 0.25(D)mm

NEW 2013

White	ZD-0473
Warm White	ZD-0487
Red	ZD-0475
Blue	ZD-0479

SUBWOOFERS

Twin Port Subwoofer Enclosures

Dual ported subwoofer enclosures with black carpet covering. Designed for optimal performance with the Vifa 10" subwoofers (below) . All you need to do is to add the driver of your choice.

- Dimensions: 480(W) x 360(H) x 280(D)mm

Note: Vifa driver not included CS-2526

DEAL
Buy both for $210
SAVE $78.95

$39.95

Vifa 10" Subwoofer

Produce high quality sound. With dual voice coils, high power handling and die-cast aluminium chassis, they don't just deliver brilliant low-register bass clarity but also thump tremendous SPLs like only Vifa speakers can.

- 200WRMS @ 2 x 4 ohms

CS-2351
WAS $249.00

$199.00
SAVE $50.00

RESPONSE PRECISION CAR AMPLIFIERS

RESPONSE PRECISION

With improved heat sinks and upgraded low-profile chassis design, each model delivers surprising grunt and performance in a sleek and compact package that fits neatly under a car seat. All include gold plated power and speaker terminals and variable low pass filters. Our class AB amps come with variable high pass filters and pass through RCAs; while our class D subwoofer amps feature variable subsonic filter, phase shift and master/slave operation.

2 x 80WRMS Class AB Amplifier

Dimensions: 266(L) x 235(W) x 58(D)mm
AA-0450 WAS $149.00 **NOW $129.00** SAVE $20.00

4 x 50WRMS Class AB Amplifier

Dimensions: 316(L) x 235(W) x 58(D)mm
AA-0451 WAS $199.00 **NOW $169.00** SAVE $30.00

2 x 150WRMS Class AB Amplifier

Dimensions: 376(L) x 235(W) x 58(D)mm
AA-0452 WAS $229.00 **NOW $199.00** SAVE $30.00

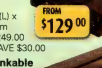
4 x 100WRMS Class AB Amplifier

Dimensions: 436(L) x 235(W) x 58(D)mm
AA-0453 WAS $299.00 **NOW $249.00** SAVE $50.00

500WRMS Linkable Class D Subwoofer Amplifier

Dimensions: 232(L) x 178(W) x 58(D)mm
AA-0454 WAS $249.00
NOW $219.00 SAVE $30.00

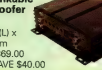
FROM $129.00



AA-0450

1000WRMS Linkable Class D Subwoofer Amplifier

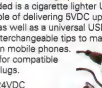
Dimensions: 306(L) x 178(W) x 58(D)mm
AA-0455 WAS $369.00
NOW $329.00 SAVE $40.00



AA-0455

UNIVERSAL USB MOBILE PHONE CAR CHARGER

The handy solution to charge your mobile phone in the car. Included is a cigarette lighter USB car charger capable of delivering 5VDC up to 1A via the USB output, as well as a universal USB charging lead with 9 interchangeable tips to match all the most common mobile phones. See website for compatible phones and plugs.



- Input: 12 - 24VDC
- Output: 5VDC, 1.0A

MP-3578

$19.95

NEW 2013

REAR VIEW MIRROR TFT MONITOR WITH CAMERA

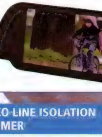
A complete rear-view safety package including a 7" TFT LCD monitor and a flush mount weatherproof camera. It has adjustable spring-loaded brackets to fit different sized mirrors. Composite video input. Includes slimline remote control, 5-metre video/power cable and 28mm holesaw for camera mounting.

- 7 inch screen
- Mirror Dimensions: 260(L) x 108(H) x 60(D)mm

QM-3762 WAS $249.00

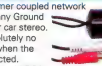
$179.00
SAVE $70.00

Note: Should not be used as a substitute for a conventional rear-view mirror but ideal when view is blocked by trailer or caravan.



CAR STEREO LINE ISOLATION TRANSFORMER

This transformer coupled network will remove any Ground Loops in your car stereo. There is absolutely no attenuation when the unit is connected. Supplied with gold RCA plugs and sockets for low level inline connection.



- Freq resp: 20 to 20kHz
- No power required

AA-3085 WAS $19.75

$12.75
SAVE $7.00

BUDGET RESPONSE CAR SPEAKERS

Low cost doesn't mean low quality. Coax speakers are an ideal replacement for the standard equipment stereo speakers you get in the average car. All are equipped with titanium coated fibre woofers and silk dome tweeters for smooth high frequency response.

4" Coax 2 Way Car Speakers

Power handling: 15WRMS
Nominal impedance: 4 ohms
Frequency response: 90Hz - 18kHz
Sensitivity: 83dB SPL 1W@1m
CS-2310 WAS $24.95
NOW $19.95 SAVE $5.00

5" Coax 2 Way Car Speakers

Power handling: 15WRMS
Nominal impedance: 4 ohms
Frequency response: 70Hz - 18kHz
Sensitivity: 85dB SPL 1W@1m
CS-2312 WAS $29.95
NOW $24.95 SAVE $5.00

6" Coax 2 Way Car Speakers

Power handling: 22WRMS
Nominal impedance: 4 ohms
Frequency response: 60Hz - 20kHz
Sensitivity: 88dB SPL 1W@1m
CS-2314 WAS $34.95
NOW $29.95 SAVE $5.00

6 x 9" Coax 2 Way Car Speakers

Power handling: 27WRMS
Nominal impedance: 4 ohms
Frequency response: 55Hz - 18kHz
Sensitivity: 86dB SPL 1W@1m
CS-2316 WAS $44.95
NOW $39.95 SAVE $5.00

RESPONSE

FROM $19.95

AUTOMOTIVE 8-WAY PLUG/SOCKET - 250 SERIES

NEW 2013

Used in automotive applications such as stereo and CB installations, or for replacements in existing wiring.

- Comes with plug, socket, and male and female locking spade lugs

PP-2069

$6.95

MACHINED BRASS BUSBAR - 8 WAY

Machined brass busbar used to give electrical common point for wiring, also useful for low voltage tie points such as on boats, RVs or caravans. Conservative insulation rating of 1000V.

- All screws M4.0 Brass bar 9.0 x 6.0
- Length overall including standoffs: 100mm, without standoffs: 65mm.

SZ-2003

$6.95

NEW 2013

KITS FOR KIDS

8-in-1 Solar Educational Kit

Your kids will love constructing one of 8 scientific kits that will not only keep them occupied for hours but they will also learn about solar technology. No tools, soldering or glue required. The finished projects are solar powered, but can also be powered by a 50W halogen light. Each project is easy and fun to build with a detailed instruction manual included.

- Projects: car, riverboat, octopus, spaceship, solar LED, robot, windmill, space alien
- Adjustable solar panel
- Suitable for ages 8+
- Solar panel dimensions: 80(L) x 35(W)mm

KJ-8925

NEW

$39.95

"ALL TERRAIN" Multi Function Tracked Robot

Very robust all terrain multi function tracked robot kit - very detailed instruction manual to help you put this kit together. Comes with 6 terrestrial tracks/crawlers. Can be reconfigured to operate as a gripper, rover or forklift type mechanism. Electric motors included.

- Batteries AA x 4 (not included)
- Dimensions of gripper robot: 90(H) x 160(W) x 270(L)mm

KJ-8918

NEW

$49.95

Wind Powered Eco-biker

This cute little kit assembles up into a wind turbine powered model bicycle rider. The wind turbine operates the rider's arms, legs and body. If the wind is strong enough it generates enough electricity to run the bikes LED headlight! The assembled unit is designed to mount in the neck of a soft-drink bottle or - appropriately - on the handlebars of a bicycle. Mounting parts included.

- Total rider/assembly: 125(H) x 100(L) x 90(W)mm

KJ-8923

NEW

$19.95

Salt Water Fuel Cell Powered Car

This car uses a simple, environmentally friendly fuel cell to power small electric car for hours of very safe fun. All that you have to add is water and table salt! Comes as a self-assembly kit. Includes 3 fuel cell sheets, non woven fabric separator and air cathode.

- Suitable for ages 8+
- Car measures: 75(L) x 40(W) x 18(H) mm

KJ-8921

NEW

$19.95

MARINE ENGINE SPEED EQUALISER KIT

Refer: Silicon Chip Magazine November 2009

Avoid unnecessary noise and vibration in twin-engine boats. The Engine Speed Equaliser Kit takes the tacho signals from each motor and displays the output on a meter that is centred when both motors are running at the same RPM. When there's a mismatch, the meter shows which motor is running faster and by how much. Simply adjust the throttles to suit. Short form kit only, requires moving coil panel meter (QP-5010).

- 12VDC
- PCB: 105 x 63mm

KC-5488

$39.95

FLICKERING FLAME LIGHTING

Refer: Silicon Chip Magazine October 1997

This lighting effect uses a single 20 watt halogen lamp (the same as those used for domestic down lights) to mimic its namesake. Mounted on a compact PCB, it operates from 12VDC and uses just a handful of readily available components. Use it for stage performances or for unique lighting effects at home.

- Kit includes 20W halogen lamp, PCB plus electronic components
- PCB: 38 x 58mm

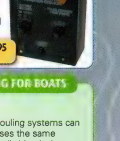
KC-5234

$16.95

SLA BATTERY HEALTH CHECKER KIT

Refer: Silicon Chip Magazine August 2009

Checks the health of SLA batteries prior to charging or zapping with a simple LED condition indication of fair, poor, good etc.



- Overlay PCB and electronic components
- Case with machined and silk-screened front panel
- PCB: 185 x 101mm

KC-5482

$79.95

SECURITY KITS

UHF Rolling Code Remote Switch Kit

Refer: Silicon Chip Magazine August/September 2009

High-security 3-channel remote control that can be used for keyless entry into residential or commercial premises or for controlling garage doors and lights. Features rolling code / code hopping, the access codes can't be intercepted and decoded by undesirables. The transmitter kit includes a three button key fob case and runs on a 12V remote control battery. The receiver is a short-form kit without case so you can mount it in the location or enclosure of choice.

- Receiver 12VDC @ 150mA (1A for door strike use)
- Additional Transmitter Kit available

KC-5484 $39.95

- PCB: Transmitter: 34 x 86mm
- Receiver: 110 x 141mm

KC-5483

$99.95

Rolling Code Infrared Keyless Entry System

Refer: Silicon Chip Magazine October 2007

This keyless entry system features two independent door strike outputs and will recognise up to 16 separate key fobs. The system keeps the coded key fobs synchronised to the receiver and compensates for random button presses while the fobs are out of range. Supplied with solder masked and silk screen printed PCB, two programmed micros, battery and all electronic components.

- Receiver requires a 12VDC 1.5A power supply
- Some SMD soldering is required
- PCB: 61 x 122mm

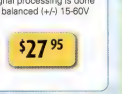
KC-5458

$64.95

BRIDGE MODE ADAPTOR FOR STEREO AMPLIFIERS

Refer: Silicon Chip Magazine July 2008

Enables you to run a stereo amplifier in 'Bridged Mode' to effectively double the power available to drive a single speaker. There are no modifications required on the amplifier and the signal processing is done by this clever kit. Requires balanced (+/-) 15-60V power supply.



- Supplied with silk screened PCB and components
- PCB: 103 x 86mm

KC-5469

$27.95

VOLTAGE MODIFIER KIT FOR CARS

Refer: Silicon Chip Magazine December 2009

This kit intercepts and alters the signal from engine sensors that supply a voltage signal to the engine control unit (ECU). Restore correct air/fuel ratios after engine modifications, prevent engine boost cuts or alter sensor signals for improved driveability. Requires hand controller for programming, RS-232 cable and a suitable input signal.

- Includes PCB, case and electronic components
- 12VDC
- PCB: 87 x 105mm

KC-5490

$79.95

ULTRASONIC ANTIFOULING FOR BOATS

Refer: Silicon Chip Magazine September/October 2010

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in sturdy polyurethane housings. By building yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/ wind generator
- PCB: 78 x 104mm

KC-5498

$249.00

Clearance Sale

BUY NOW SAVE $$$ Over 20 to 75% off all listed items

Listed below are a number of discontinued items that we can no longer afford to hold stock. We need space in our stores!
You can get most of these items from your local store but we can not guarantee this. Please ring your local store to check stock.
At these prices we won't be able to ship from store to store. ITEMS WILL SELL FAST AND STOCK IS LIMITED.
ACT NOW TO AVOID DISSAPOINTMENT. Sorry NO RAINCHECKS.

Audio/Video Products

Product Description	Cat No	Original RRP $	Special Price $	Save $
Antenna - 2.4GHz Ceiling-Mount	AR-3271	$49.95	$12.95	$37.00
Antenna - 2.4GHz Compact Yagi 8dB Gain	AR-3272	$99.00	$29.00	$70.00
Antenna - 2.4GHz Wall-Mount Panel	AR-3275	$89.95	$22.95	$67.00
Antenna - 3.5GHz Flat Panel 12dB with Bracket	AR-3274	$119.95	$43.95	$76.00
Audio Video Modulator 2.4GHz - Transmitter	AR-3698	$19.95	$7.95	$12.00
AV Sender/Receiver 2.4GHz	AR-1836	$76.95	$34.95	$42.00
Clip-on Chromatic Tuners	AA-2041	$14.95	$8.95	$6.00
DAB+ & FM Radio Tuner Compact	AR-1751	$99.00	$57.00	$22.00
DAB+ Digital Radio	AR-1750	$139.00	$67.00	$72.00
Dual HD DVB TV Tuner and Recorder with HDMI	XC-4918	$399.00	$359.00	$40.00
HDMI Cable 1.8m Bargain	WQ-7414	$9.95	$3.95	$6.00
HDMI Extender/Repeater	AC-1697	$54.95	$19.95	$35.00
HDMI In-Line Repeater/Extender	AC-1698	$79.95	$24.95	$55.00
HDMI Wall Plate Socket Double	PS-0286	$29.95	$9.95	$20.00
Headphone/Earbuds Wireless with USB Transmitter	AA-2035	$99.95	$49.00	$50.95
High Definition Digital TV Set-Top Box	XC-4916	$99.00	$80.00	$19.00
Micro USB Digital Tuner	XC-4897	$99.95	$71.95	$28.00
Shielded VHF UHF Diplexer for Digital TV	LT-3080	$69.95	$34.95	$35.00
Speaker 12" Foldback	CS-2516	$169.00	$116.00	$53.00
Speaker Selector 8 Way with Impedance Matching	AC-1682	$134.00	$65.00	$69.00
Video Distribution Amplifier 4 Output	QC-3439	$119.00	$80.00	$39.00
Video Distribution Amplifier Dual Output	QC-3436	$89.00	$49.00	$40.00
Video Splitter - Two Output	QC-3435	$59.95	$24.95	$35.00
Video Transmitter - Long Range	QC-3425	$179.00	$49.00	$130.00

Automotive & Outdoors Products

Product Description	Cat No	Original RRP $	Special Price $	Save $
Bluetooth Hands Free with MP3 Transmitter	AR-1862	$69.95	$64.95	$5.00
Charger Car Solar Battery Booster	MB-3923	$37.95	$17.95	$20.00
Charger In Car Mobile Phone	MB-3546	$19.95	$9.95	$10.00
Fixed Attenuators	LT-3051	$9.95	$2.95	$7.00
Globe Bayonet Car 24V 21W	SL-2719	$1.65	$0.45	$1.20
In-Dash Multimedia Player with 3" TFT Screen	QM-3787	$385.00	$179.00	$206.00
Reversing Sensor with Dashboard Display	LR-8869	$149.00	$134.00	$15.00
Speaker Car Kit 6"x 9" 4 Way 150WRMS	CS-2397	$189.00	$134.00	$55.00
Speaker Car Vfa 6.5" Splits 80WRMS	CS-2399	$199.00	$170.00	$29.00
Speaker Grille Clamp Kit / "T" nuts	AA-3530	$1.95	$1.50	$0.45
Speaker Grille Clamp Kit / "T" nuts	AA-3542	$4.70	$1.30	$3.40
Speaker Mini LED Screw	AS-3024	$8.95	$1.95	$7.00
Speaker Tweeter Piezo Horn - 400W	CT-1934	$29.95	$18.95	$11.00
Stereo Bluetooth Adaptor	AR-1854	$69.95	$22.95	$47.00

General Consumer Products

Product Description	Cat No	Original RRP $	Special Price $	Save $
2.4GHz 8 Channel Car Remote	DC-1500	$149.00	$134.00	$15.00
Battery Operated Water Pump	GH-1118	$14.95	$12.95	$2.00
BBQ Tool Set Pink	GQ-2307	$24.95	$9.95	$15.00
Calculator Desk Printer	GH-1871	$9.95	$8.95	$1.00
Chess Board with Robot Arm	GT-3516	$299.00	$206.00	$93.00
Digital Photo & Video Camera for Kids	QC-3188	$49.95	$34.95	$15.00
Helicopter 3Ch Mini IR	GT-3272	$39.95	$34.95	$5.00
Helicopter 4Ch Mini with Remote Recharge	GT-3279	$79.95	$64.95	$15.00
Helicopter Jumping RC	GT-3263	$119.00	$59.00	$60.00
Houseplant Watering System Deluxe	GH-1255	$79.95	$14.95	$65.00
Human Brain Puzzle Game	GG-2383	$24.95	$21.95	$3.00
Human Ear Anatomy Puzzle	GG-2382	$24.95	$21.95	$3.00
Human Eye Anatomy Puzzle	GG-2381	$24.95	$21.95	$3.00
Human Skeleton Anatomy Puzzle	GG-2385	$24.95	$21.95	$3.00
Human Skin Model	GG-2377	$24.95	$21.95	$3.00
Pedometer with LED Torch	QC-0326	$8.95	$1.95	$7.00
Photo Frame Digital 3.5"	QM-2779	$59.95	$29.95	$30.00
Photo Frame Digital 7"	QM-3777	$99.00	$52.00	$47.00
Portable Stove	YS-2807	$49.95	$14.95	$35.00
RC Car - Audi R8 27MHz	GT-3696	$59.95	$44.95	$15.00
RC Car - Ferrari 2008 F1 1:10 Scale	GT-3201	$59.95	$44.95	$15.00
RC Car - Lamborghini Reventón 27MHz	GT-3692	$59.95	$44.95	$15.00
RC Wall Climbing Battle Cars	GT-3285	$79.95	$24.95	$55.00

Product Description	Cat No	Original RRP $	Special Price $	Save $
Remote Command-A-Man	GT-3170	$9.95	$1.00	$8.95
Talking Swear Box	GH-1318	$19.95	$8.95	$11.00
USB Keyboard with Rhinestones	GH-1899	$59.95	$29.95	$30.00
Voice Recorder Digital 2GB	XC-0382	$129.00	$80.00	$49.00

Power Products

Product Description	Cat No	Original RRP $	Special Price $	Save $
2.5V 1W Torch Globe Bi-Pin Type	SL-3212	$1.20	$0.07	$1.13
AAA Battery Bank with Alligator Clips and Switch	MP-3071	$9.95	$4.95	$5.00
Cliplights - Low Voltage Outdoor Lighting System	SL-2810	$1.75	$0.50	$1.25
Globe Halogen 12V 50W 38D Lens Red	SL-2741	$7.95	$2.50	$5.45
Globe Halogen MR16 12V 20W	SL-2729	$7.45	$1.95	$5.50
Globe Halogen MR16 24V 50W	SL-2737	$8.95	$2.50	$6.45
Head Torch 1W Multicolour 4 LED	SL-2288	$14.95	$17.95	$17.00
Heavy Duty 70 Amp Battery Power Selector	MB-3672	$99.95	$34.95	$65.00
Light - Fluoro for Cabin Lamp ST300B	ST-3007	$16.95	$9.95	$7.00
Light - Fluoro Tube 12VDC Cabin Lamp	ST-3006	$39.95	$22.95	$17.00
Light - LED Recessed Blue	ST-3388	$19.95	$10.00	$9.95
Light - Fluoro 6W/4 Compact Red	SL-3153	$22.95	$7.95	$15.00
Light - Fluoro 8W/4 Compact Red	SL-3154	$25.95	$7.95	$18.00
PAR-56 Black Can Light	SL-2974	$58.95	$34.95	$24.00
PEM Fuel Cell Module - 300mW	ZM-0089	$99.00	$30.00	$69.00
Reflector Caps	SL-2816	$6.95	$2.95	$4.00
RF Remote Controlled Receiver 240V	MS-3258	$29.95	$11.95	$18.00
Single 240V GPO w/ Extra Switch	PS-4044	$6.95	$2.95	$4.00
Solar Lighting System 10W	MP-4552	$219.00	$134.00	$85.00
Solar Lighting System 40W	MP-4554	$499.00	$359.00	$140.00
Solar Lighting System 5W	MP-4551	$189.00	$89.00	$100.00
Spotlight 10 Million Candle Power	ST-3308	$99.95	$27.00	$72.95
Spotlight Solar Powered LED	SL-2716	$149.00	$89.00	$60.00
Switchmode Power Supply 6VDC 2.5mm Plug	MP-3232	$23.95	$6.95	$17.00
Torch Dynamo Pocket Silver	ST-3331	$14.95	$13.95	$1.00
Torch LED Keying with Solar Charging	ST-3389	$9.95	$5.95	$4.00
Torch Mini LED - Red	ST-3384	$4.50	$1.50	$3.00
Wireless LED Wall Light	ST-3178	$29.95	$8.95	$21.00

Security & Surveillance Products

Product Description	Cat No	Original RRP $	Special Price $	Save $
4-Channel to USB Video Adaptor	QV-8000	$69.00	$45.00	$24.00
Alarm Kit 4-Zone Wireless Economy	LA-8134	$99.95	$45.00	$54.95
Alarm Relay Module	LA-5555	$23.95	$21.95	$2.00
AV-GAD 8 Zone Alarm Panel with Keypad	LA-8512	$449.00	$404.00	$45.00
AV-GAD Alarm Package - 5 Zone	LA-8484	$599.00	$539.00	$60.00
AV-GAD Eye Spy 11 Passive Infrared Detector	LA-8532	$59.95	$54.95	$5.00
AV-GAD Eye Spy LCD Keypad (AV-7078)	LA-8520	$179.00	$159.00	$20.00
AV-GAD Professional Alarm Package - 8 Zone	LA-5468	$999.00	$899.00	$100.00
Camera CCD Shield Infrared Activity Sensor	QC-3462	$99.00	$87.00	$12.00
Camera CCD Dome Style B&W 380TVL	QC-3472	$89.00	$28.00	$61.00
Camera CCD Dome Style Colour 550TVL	QC-3498	$279.00	$116.00	$163.00
Camera CCD Dome Style Low Cost - Sheep Sensor	QC-3291	$89.00	$36.00	$53.00
Camera CCD Dome Style Vari-Focal 480TVL	QC-3297	$299.00	$197.00	$102.00
Camera CCD Downlight Style Colour	QC-3503	$249.00	$159.00	$90.00
Camera CCD Mini B&W in Metal Case with Audio	QC-3474	$69.00	$44.00	$25.00
Camera CCD Mini Reversing Colour	QC-3727	$249.00	$134.00	$115.00
Camera CCD Pro Style B&W 380TVL	QC-3310	$139.00	$75.00	$64.00
Camera CCD Pro Style Colour 350TVL	QC-3309	$179.00	$71.00	$108.00
Camera CCD Pro Style Dummy with Beacon	QC-3303	$199.00	$104.00	$95.00
Camera CCD Pro Style Hi-Res Colour 520TVL	QC-3307	$299.00	$134.00	$165.00
Camera CMOS Mini 5.8GHz Wireless Colour	QC-3571	$179.00	$62.00	$117.00
Camera Dome Dummy with Beacon	LA-8512	$29.95	$7.95	$22.00
Camera Dome Style Dummy 3-Axis	QC-8615	$39.95	$34.95	$5.00
Camera Dome Style Colour 480TVL	QC-3502	$249.00	$149.00	$100.00
Mini Digital Spy Recorder 2MP	QC-9001	$149.00	$80.00	$69.00
Mini Portable Security Recorder	QV-0094	$349.00	$134.00	$215.00
Motorised Pan Alarm	LA-8020	$59.95	$54.95	$5.00
RFID Keypad Access Controller	LA-5123	$169.00	$50.00	$119.00
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SERVICEMAN'S LOG

There's just no pleasing some people

While we prefer satisfied customers, every now and then we strike someone who, try as we might, we just can't seem to please. I don't let it get to me but for those new to service work or inexperienced at dealing with customers, an unreasonable client can cause sleepless nights.

I'd like to say that out of thousands of clients I've had over the years, I've never had such a customer – but I'd be lying. To be honest, I don't think one can be in business – or at least a business where you have to deal closely with customers – and not strike at least one or two disgruntled clients. This story is about one of them and if you are a service person, you may recognise a similar situation in your own experience.

As is usual, my relationship with this one started out happy and stress-free. She was the wife of a friend's friend and while I had met her before, we weren't exactly close. She wanted a new computer and since I had been running my business for a while, she'd heard that's what I did and asked if I could build a system for her?

After sorting out the specifications and price, she gave me the go-ahead and I set about sourcing the parts and doing the build. At 7am the next morning, I got a call asking if the machine was ready. My negative reply seemed to annoy her (at least, that's what the tone of her voice indicated) and she immediately demanded to know when it would be ready.

My response was that I was still waiting on a couple of parts and in any case, I like to burn new systems in for a day or so, to make sure they won't fall over. Such things can happen and it is better for a new machine to fail on my workbench than after it has been delivered to the customer.

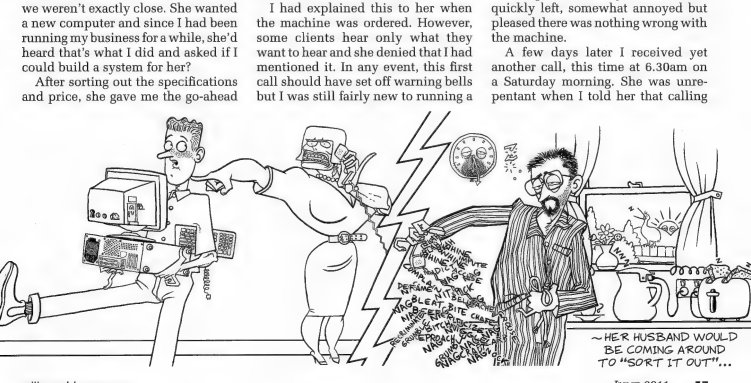
I had explained this to her when the machine was ordered. However, some clients hear only what they want to hear and she denied that I had mentioned it. In any event, this first call should have set off warning bells but I was still fairly new to running a business and ignorance can be bliss.

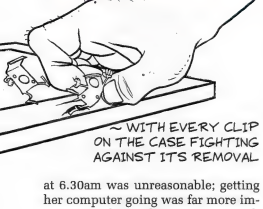
A few days later, I delivered the system and everyone was all smiles again. It ripped along nicely and the software she had purchased for it installed and ran well. And so, with the cheque duly banked, I created a scheduler task to call her in two weeks, to see how things were going and to offer any other help.

Alas, I heard from her in two days; the machine wouldn't turn on. I went through my usual phone procedure to ensure things were plugged in and powered up and they all were. It was a mystery until I went around there and discovered she was trying to push a plastic moulding which was not the power button. Instead, the real power switch was located below this, under another admittedly similar-looking but moveable piece of plastic with "Power" clearly printed on it.

When I explained this, she looked horrified for a brief moment before launching into a spiel about how she was pushing that one but it wasn't working. I made my excuses and quickly left, somewhat annoyed but pleased there was nothing wrong with the machine.

A few days later I received yet another call, this time at 6.30am on a Saturday morning. She was unrepentant when I told her that calling





at 6.30am was unreasonable; getting her computer going was far more important as far as she was concerned. This time, she claimed that the 17-inch CRT monitor I'd sold her was failing and that the hardware I had supplied was rubbish. She also said that she should have known I couldn't deliver a better quality machine than company "X" and that she would be seeking a refund and that her husband would be coming around to "sort it out".

To be honest, I had tuned out of the tirade by then. Instead, I told her that if she had a problem with the hardware, all she needed to do was bring it back and it would be dealt with under the warranty.

Well, her husband did come around and he brought the monitor with him. I plugged it in and it worked perfectly, though he said that at their place the image was all distorted and the colours were way off. I couldn't explain that one; my thoughts went to either an intermittent cable connection or even the graphics card failing, although this seemed unlikely.

In the end, we decided to go back to their house and test it in-situ. With the monitor back in position, I connected it to the computer while the wife rearranged various ornaments around it, with one even going on top. And sure enough, when we turned it on, the image was pulled upwards and it displayed some very odd colours.

It didn't take a genius to figure out it was the magnetic sculpture she had placed on top of the monitor. This magnetic doo-dad consisted of a heavy magnetic base and hundreds of tiny star-shaped metal pieces that could be infinitely rearranged and held in place by the strong magnetic field. Of course, this played havoc with the CRT and once I removed it and degaussed the monitor, everything was back to normal.

Despite the evidence, she then tried claiming that it was playing up before she put anything near it but I told her I seriously doubted that. I also said that we would happily replace the monitor if it failed but I never heard from her ever again.

I cannot decide whether that was a good thing or a bad thing – good because I didn't find her easy to deal with; bad because I may have lost a customer through no fault of my own.

Laptop fan maintenance

Laptops can really get my hackles up. I say this because while they are without doubt incredibly useful (and often indispensable), my servicing experiences have dampened my enthusiasm for them. A classic scene in our workshop is the air turning blue as one of us struggles to find that last screw or clip holding the whole thing together.

No matter how many laptops I pull apart, it seems like each model is unique when it comes to screw positions, clips and cable connections. Some machines just about fall apart, while others fight every step of the way. I swear they are designed by the same people who made British cars in the 1950s and 1960s, with impossible-to-access screws buried under panels behind covers beneath stickers.

When servicing a laptop, one of our most common maintenance tasks is to clean out the ventilation holes, the CPU heatsink and any fans. This is because cooling systems in many laptops are barely adequate even when new. Throw in a layer of nicotine-flavoured grime on the ducting and things soon start heating up, especially if the fan has slowed down due to wear and tear and lack of lubrication.

Now you'd think that the manufacturers would keep this in mind and put the whole caboodle under one easy-to-access panel. But no; out of the hundreds of laptops I've serviced over the years, I have struck only a handful where this is the case.

Not only are the fans typically at the bottom of the disassembly chain, even when you get there you aren't really there yet. Often, any air gaps will have been sealed with "stick-like-you-know-what to a blanket" single-application tape. This then has to be ruined in order to be able to remove the parts underneath. And because we can't buy this exact-same tape, everything from gaffer tape to duct tape is pressed into use as a substitute.

Then there are the fans themselves. Most are considered non-repairable and are enclosed in sealed metal cases which are crimped or folded together. So in order to expose the bearing surfaces for lubrication, you need to either drill a small hole through the case and risk damaging the fan or pry the thing apart in the hope that you can get it all back together again.

And if you do get it back together again, it had better be just as compact and dent-free as when you started, otherwise the fan will rub against it and nothing will fit at all.

Once you get to the cooling components, cleaning them is easy. My major gripe is the fact that you have to disassemble and virtually half-wreck everything in order to get to them and complete what should be a very simple job. When you present the invoice to the client, "clean and lubricate fans" doesn't really reflect the actual labour involved.

Instead, it's just one of many "simple" jobs we have to regularly undercharge in order to maintain customer goodwill.

Insurance reports

It's not unusual for us to be asked to write reports for clients making claims against insurance policies. In my line of work, this is usually when a laptop has been accidentally damaged because either something has been spilt on it or it has been dropped. Desktop machines can also suffer accidental damage, eg, when a nasty power surge takes out the power supply and everything else in the case.

More recently, because we live in Christchurch, it has been earthquake damage reports and lots of them. In the majority of cases, this involves generating a report stating what we believe happened to the equipment, the damage done and the approximate cost of repair. We've done so many that we now have a large collection of "templates" on file for the most common problems and misadventures.

This means that, when a new insur-

ance job comes in, all we have to do is change the relevant client details and add or remove any model or claim-specific information before hitting "Print" or "Send". There is no point wasting time and energy generating new reports from scratch when there is one almost ready to go except for a few sundry details.

In 99% of cases, this allows us to trot out a comprehensive report that will satisfy the most jaded assessor/adjuster. However, human nature being what it is, every now and then we get a customer who wants to bend the truth and aim a little higher than they know they should. However, while it's not unusual for people to overestimate what their hardware is worth, it's quite another thing to deliberately try to diddle some "free" money from insurance companies.

I don't doubt that there are some service people out there who have no qualms about making inflated claims on behalf of clients, their rationale being that this is a "victimless crime" and therefore somehow acceptable. The problem is, legitimate customers ultimately end up covering the losses incurred by frauds and scams by way of higher premiums, so it's hardly a victimless crime.

We always try to be scrupulously fair in our reports. We listen carefully to what the client tells us and as long as the damage and evidence bears that out, there is no problem in making claim. Determining the replacement cost can be tricky though. After all, computer equipment that may fetch just $150.00 in today's market may have cost the client a thousand dollars or more just a few years ago.

As a result, we compare their hardware with what is available now and set our estimate at what similar replacement equipment would cost. That means that the client gets a "like for like" replacement, which I think is the fairest outcome for everyone concerned.

For example, if the damaged machine sported an expensive motherboard, dual high-end video cards and other expensive parts, then our estimate would be based on the cost of a similar machine using current high-end technology. Similarly, if it used mid-range hardware, then our estimate would be for a machine with mid-range hardware. We do have to take into account the age of the damaged equipment in making our estimates though.

Of course, all this only holds good if the insurance people listen to us and take our advice. All too often we get them coming back and valuing the machine at a lower figure, usually because they have arrived at their estimate using cheaper or lower-quality replacement hardware.

That puts us in a tough position because the clients often come back to us, concerned with the disparity. In the end, most are willing to take the cash on offer and add whatever is required to make up the difference to get the machine they want, rather than opt for a lower-end machine.

It's also a tough call if it's a major client pushing for a false appraisal, because turning them down will likely result in the loss of their business. However, tempting as it might be to keep onside with them, a prosecution for insurance fraud doesn't look good on the CV and we'd risk losing far more than one client, so our answer is always an uncompromising "no". It has taken me many years of hard graft to build my company and its current reputation and I am not about to jeopardise that for the sake of one client, no matter how important they may appear to be to our business.

Besides, I have to be able to sleep at night.

The koala did it

In this age of natural disasters and shrinking computer repairs, any job we can charge for is fair game. We are prepared to take on just about anything and so a wide variety of items find their way onto the workbench.

One such job appeared the other day and I had to double-check just to be sure the client really wanted to spend money getting this item repaired. That's because it was a bog-standard halogen desk lamp, the likes of which can be purchased at many stores for as little as $10.

This one featured a small, rounded head-unit housing the reflector, halogen bulb and cover glass. This assembly sat atop what appeared to be two telescopic transistor radio aerials

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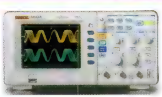

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pressed into service to form the "stalk" of the lamp. These two "aerials" ran parallel to each other, about 40mm apart, all the way down to a heavy base unit some 250-300mm below. This dome-shaped base housed the on/off switch and the components required to power the lamp.

The only real difference I could see between this lamp and other similar lamps was that this unit had a company logo screen-printed on it. Apparently, it had sentimental value and the client wanted us to "have a look" to see if we could do anything with it. The reported symptoms were low-to-no light output and the base was getting hot.

Looking underneath, I could see the removable bottom was indeed slightly heat-warped, which is never a good sign. The screws were hidden under the rubber feet which crumbled into rubber dust as I carefully tried to prise them clear. Once the screws had been undone, the base dropped away to reveal a hefty-looking transformer and, well, nothing else.

Not having disassembled one of these before, I was mildly surprised to find just a tranny hiding in there. It made sense though; the bulb only needed 12V AC and the transformer stepped the juice down from 230/240V AC to the required voltage. This was then fed to the bulb assembly via the two telescopic "aerials".

I was quite surprised at this. Initially, I had assumed that the wires ran up the hollow insides of the "aerials". However, in this lamp, the "aerials" are themselves the conductors, ie, they are live, albeit with just 12V AC across them.

A quick check with the multimeter revealed the secondary of the transformer to be open-circuit. Fortunately, we had one in stock that was about the same size, physically and electrically. Using Ohm's Law, I calculated the 20W bulb's approximate current draw to be 1.66A and although I had no idea of the replacement transformer's exact specifications, it certainly looked capable of doing the job.

Anyway, I fitted the transformer and the happy client took her now-working lamp home. However, a few days later it was back with the same problem. This time, however, the heat damage was more pronounced.

Puzzled by this, I quizzed the client as to where the lamp sat and asked if anything nearby touched it or obscured the rather limited air-cooling vents. In the end, with no obvious answers, I replaced the transformer and back it went, with me thinking that that would be the end of it.

But no; she back was on the phone the very next day claiming the lamp was very dim and "smelled hot". I asked her to turn it off, not touch anything and wait for me to get there.

As soon as I saw it, things began to make sense. Once she'd put the lamp back on her desk, she'd set about replacing all the trinkets and "objets d'art" that usually lived around it. She had also clipped a small souvenir koala bear (the type which "grabs" anything placed between its spring-loaded forepaws) half-way up the telescopic "aerials". However, due to the way she'd attached it, the sprung metal clip inside the souvenir touched and therefore bridged both "aerials", effectively shorting out the secondary of the transformer.

As soon as I moved the clip away from one of the aerials, the lamp burst back into life. And so the problem was easily solved although I have to say that the design of this unit leaves something to be desired.

These days, margins are such that service work is usually only profitable if a job is done once. Any warranty claims or any further unpaid work will eat up any profit. In this case, I did the job twice and stood the cost of the first transformer as well, not to mention the time I spent going around to the client's house.

To offset the possibility of having to revisit jobs, we try to ask the right questions to nail down what the problem might be. It also helps if clients answer these questions as accurately as possible. In this case, I specifically asked this client if anything was touching the lamp when it was in use and you'd think that physically clipping something onto the lamp would fall into the category.

I'm also surprised the client didn't "click" that the lamp stopped working when she clipped the koala to it. Oh well, just another day at the office!

My next story is from A. F. of Chinderah, NSW and concerns an air-conditioner that was repeatedly failing. Here's how he tells it . . .

Recalcitrant air-conditioner

Enid is an elderly pensioner who had found the going tough since her husband died. And with her air-conditioner now on the blink, it had just got tougher.

When the unit first stopped working, a repairman charged her $100 to get it going again, which Enid gladly paid. However, a few months later, it stopped working again and Enid paid another $100. Now it had stopped

working for the third time and Enid had decided that paying her rent and keeping her car running were more important than keeping cool.

The result was that she now suffered the hot and humid weather of the Northern Rivers district in NSW while the unit stood idle.

When I heard of her plight, I immediately offered to look at the unit, more as a token of sympathy than in the hope of affecting a repair. In my younger days, I had re-gassed two refrigerators using borrowed equipment but I now no longer had the friends to help me out. I phoned a local air-conditioning company and found out that the standard call-out charge was $100. Re-gassing cost around $350, while a new system would cost about $3500. So it seemed that Enid's unit had not required re-gassing and the problem was something more minor.

Enid lived in a nice retirement village. When I got there, my first step was to remove the batteries from the A/C's remote control unit and check them on my battery tester. They tested OK and there were no signs of corrosion in the battery compartment, so I reinstalled them.

Next, I focussed my digital camera on the infrared LED end of the remote and pressed the remote's on-off button. This resulted in faint flashes of light on the camera's LCD, so it looked like the remote was working OK. However, the A/C unit on the living room wall would not respond to any button presses, so it was time to investigate both the outdoor section of the A/C and the meter box.

Enid showed me where the meter box was and as soon as I opened the door, I could see a problem. The circuit breaker marked "A/C" had tripped and I was glad that Enid was there to see the fault for herself. There was not much more I could do other than reset it, so I turned off the main switch, reset the circuit breaker and then turned the main switch back on.

In fact, this reminded me of a customer who found that a circuit breaker in his meter box had tripped. He had attempted to switch it back on without first switching off the mains. When he did so, the circuit breaker exploded as it tried to switch itself "Off" while being forced "On". In turned out that the circuit breaker had tripped because a leaking roof had caused a dead short condition.

Fortunately, there were no dramas when Enid's mains switch was flicked back to its "On" position, so it was time to see if the A/C unit would now respond to the remote. Sure enough, the A/C unit responded immediately and a delightful rush of cool air descended from the unit on the wall. Enid was thrilled.

So what had happened to trip the circuit breaker? A retired friend explained that these retirement village units had been fitted with 15A circuit breakers when they were built. Since then, the supply voltage had been reduced from 240V to 230V AC and so the A/C motors would draw more starting current. Add in the fact that the motor bearings probably now had higher friction due to ageing and it's easy to see why the circuit breaker might occasionally trip.

Fitting a new circuit breaker with a "D" curve would probably solve the problem permanently but I was content to leave my phone number with Enid. If I can save a battler $100 just by flipping two switches, then I am happy to do so. SC

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By JOHN CLARKE

VersaTimer/Switch

Use it as a micropower switch, programmable timer and/or 12V battery protector

Do you have a switching application that calls for a relay but needs very low current drain? You won't get satisfaction if you use a conventional relay – it pulls too much current. You need this circuit board which uses a 12V latching relay. As a bonus, it functions as a programmable timer and battery protector.

THIS PROJECT WAS first conceived to update the DC Relay Switch from our November 2006 issue. That project would operate a high-current relay in response to any DC or pulse signal and it also employed an optocoupler to provide full isolation between the control signal and the circuit being switched.

Now while that project was OK there has been an increasing need for a relay switching circuit which consumes the very minimum of power, whether or not the relay is energised. The problem is that all conventional relays draw some current continuously when they are energised and that can be a major drawback in battery-operated circuits.

The current through the relay coil depends on the particular relay. For 12V relays, the coil current can be as low as 12mA for a 500mA reed relay, 30mA for a 3A relay and more than 100mA for a 30A relay. This coil current must be continuously applied to keep the relay contacts closed.

The solution: use a latching relay. This type of relay only draws a brief pulse of current when its relay contacts are changed from the closed or open condition. At all other times, it draws no current at all.

So how does a latching relay work? Well, instead of just using a moving armature (to operate the contacts) together with a coil wound on a steel

core (an electromagnet), a latching relay has a couple of bar magnets and these hold the relay contacts in one position (eg, closed) or the other (eg, open). The electromagnet effectively toggles the relay contacts from one position to the other just as you do when you operate a light switch in your home. However, in the light switch example, the switch is held in the open or closed position by spring action. By contrast, the latching relay uses magnets to do the same job.

But while latching relays are good (ie, they don't draw current continuously), they are much more difficult to drive than conventional relays. The circuitry required to drive them is more complicated as we shall see.

Multiple functions

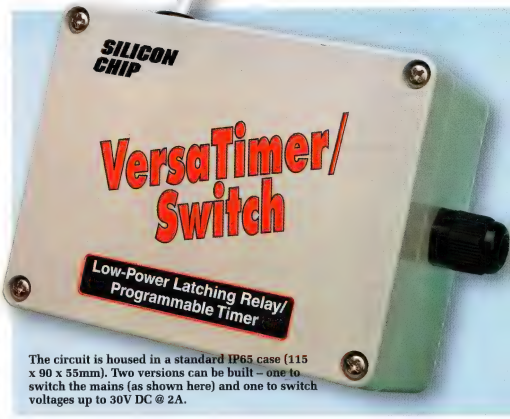
As indicated, this "VersaTimer/Switch" circuit drives a latching relay. It also provides a useful timer function which can provide latched or momentary operation and can switch power on for a predetermined period or switch it off after a predetermined period. Or it can switch on and off alternately, according to your settings.

To top it off, it also provides a battery protection feature, preventing the battery from being too heavily discharged. This is important in circuits which run from lead-acid and particularly sealed lead-acid (SLA or gel) batteries.

All these features are provided by a small PIC microcontroller. Now before you fall about laughing or reel back in dismay, stay with us while we give you the reasons for using a micro rather than a bunch of transistors and maybe a logic IC or two. Well that says it all really because a bunch of transistors and logic ICs would end up being a lot more complicated and provide less functions than our circuit. Nor would a discrete version have the low power consumption of this circuit.

Latching relays use either one or two coils to drive the relay into each state. For a single coil type, you need a pulse of current to switch from one state to the other and then a pulse in the opposite direction to change state again.

A double-coil latching relay requires a pulse of current in one coil to provide the set (on) position for the contacts and then another pulse of the same polarity to be applied to the second coil to produce the (off) reset condition for the contacts. There is more discussion on latching and non-latching relays in a separate panel at the end of this article.



The circuit is housed in a standard IP65 case (115 x 90 x 55mm). Two versions can be built – one to switch the mains (as shown here) and one to switch voltages up to 30V DC @ 2A.

The VersaTimer/Switch has been designed to suit both types of latching relay, ie, single or double-coil. The double-coil relay has DPDT 2A contacts and the single coil relay has SPST 60A (or 80A) contacts.

The drive circuitry is also suited to other latching relays that may not necessarily fit onto the PCB for the VersaTimer/Switch. Because latching relays have differing pulse length requirements when switching relay states, the pulse duration can be adjusted to suit the relay specifications.

Isolated triggering

For most uses, a trigger signal is required for the VersaTimer/Switch. This trigger signal can be 0V for one relay position and 5V for the alternative relay position. For example, the trigger can be obtained from a circuit that drives a LED or from any other suitable voltage signal.

In addition, the input trigger signal

Main Features

- Very low current drain
- Electrically isolated control input
- Low battery protection
- 60A (or 80A) 250VAC SPST relay or 2A 30VDC DPDT relay
- Relay options include input follow, alternate or momentary
- Adjustable input switching sense
- High, low or high and low switching with momentary action
- Adjustable relay drive pulse duration
- Timer periods from seconds to 5 hours

Main Uses

(1) Standalone timer
(2) Low battery power switch or battery isolator
(3) Low power relay control from DC or pulse signal

Specifications

Supply voltage	12V nominal
Relay type	12V latching
Relay drive pulse	1-500ms adjustable
Pulse current at 12V	15mA (@25ms) for SY-4060, 85mA (@60ms) for JMX-94F-A-Z
Low battery threshold	<11.5V (adjustable)
Low battery upper threshold (switch back on)	>12V
Battery voltage monitoring	6ms every 10s
Timer function	0-50s (200ms minimum, ~200ms steps), 0-5m (8.4s minimum and 36 x 8.4s steps) or 0-5h (2.38m minimum and 127 x 2.38m steps)
Isolation	2500VAC between coil and contacts for 60A and 80A relays
Trigger input isolation	up to 50V maximum recommended
Quiescent current	17µA maximum, 13.3µA measured at 12V; add 10.6µA when RB2 is low and add 0.6µA during any timing period
Low battery quiescent current	17µA
Maximum trigger voltage	35V with 10kΩ 0.25W resistor for R1
Minimum input voltage	3.25V for R1 = 10kΩ (alternative R1 for lower voltages: 1.5kΩ for 1.5V, 3kΩ for 2V, 6.2kΩ for 3V)
Minimum input trigger current at In+ and In-	225µA
Maximum input trigger current	60mA

is optically isolated and can operate from a floating potential.

Triggering can also be from a momentary pushbutton switch or toggle switch, depending on the application.

When used as a replacement for a non-latching relay, the VersaTimer/Switch responds to follow the input signal. So when the input signal is off, the relay is set to one state (for example, with its contacts open) and when the trigger signal is on (ie, trigger voltage is present) the relay is switched to its alternative state with its contacts closed. You can select which relay state occurs with which input signal.

Low voltage monitoring

This function is independent of the input triggering function. In addition, the typical current drawn by the VersaTimer/Switch is very low at around 13.3µA.

Timer function

The VersaTimer/Switch can be set to switch on or off with a trigger signal for a period from seconds through to five hours. It can be triggered from a high to low signal (eg, 5V to 0V), a low to high signal (eg, 0V to 5V) or from both voltage edges.

Circuit description

Refer now to Fig.1 for the complete circuit for the VersaTimer/Switch. It's based on a PIC16F88-I/P microcontroller (IC1) which monitors the input trigger signal and drives the latching relay via transistors Q1-Q6. It also monitors the inputs that define all the circuit functions, including low battery protection.

The trigger input is via IC2, a 4N28 optocoupler. This comprises an infrared LED and phototransistor in a 6-pin DIP package. When the infrared LED is not driven (off), the phototransistor is off. When the LED is on, the phototransistor is switched on. It can be driven by either AC or DC signals, since the internal LED is shunted with diode D4.

The optocoupler provides isolation for the trigger input. This isolation allows the input LED to be driven from a signal that is not referenced to the supply ground of the VersaTimer/Switch. We recommend a maximum of 50V between the LED drive signal and the supply ground for the VersaTimer/Switch.

The input trigger current is typically 400µA when 5V is connected between the input "+" and "–" terminals. This current is set by the 10kΩ limiting resistor (R1) and the 1V drop across the infrared LED. Minimum input trigger current is 225µA and so the input voltage can be as low as 3.25V, with a 10kΩ resistor. For lower input voltages, R1 can be changed to 1.5kΩ for 1.5V, 3kΩ for 2V and 6.2kΩ for 3V.

The phototransistor inside IC2 is tied to the high (+5V) RB1 output of IC1 via a 470kΩ resistor. A 220nF capacitor keeps RB2 low when a low-voltage 50Hz AC signal is applied to the trigger input. The 100Ω resistor is included at the emitter of the optocoupler transistor to limit the current when discharging the 220nF capacitor. S1 is included as a test switch to check the operation of the relay switching.

Power saving strategies

There are a number of aspects of this design which are included to save power.

If the battery voltage is low, the 470kΩ pull-up resistor at RB2 is tied low via the RB1 output. This reduces the current flow should the phototransistor within IC2 be conducting due to infrared LED current. This feature reduces the supply current by 10.6µA when IC2 is conducting.

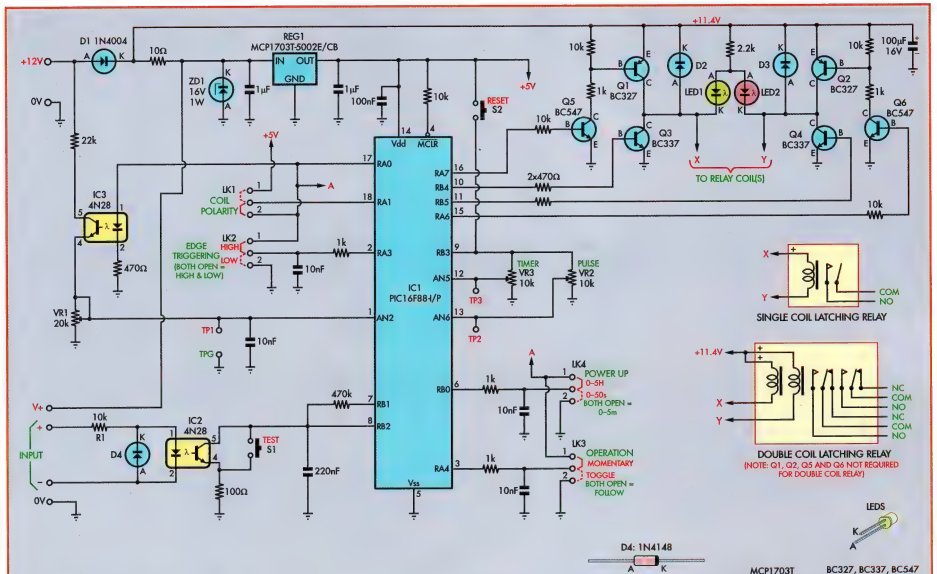
While IC2 provides isolation of the input trigger signal, optocoupler IC3 is included simply to save power. IC3 is turned on when the RA0 output of IC1 goes high, to drive the internal infrared LED. This turns on IC3's phototransistor to connect the voltage divider comprising the 22kΩ resistor and VR1 across the input supply, so that it can be monitored by the AN2 input.

If this divider were permanently connected, then the current would be 363µA. By turning on the optocoupler for just 6ms every 10 seconds, we use 6.4mA to briefly drive the optocoupler LED but the average current to monitor the battery voltage drops to just 4µA.

Power is also saved by running IC1 at 31.25kHz using an internal oscillator and divider. At this frequency, the microcontroller itself draws a mere 35µA. That's pretty good but IC1 is also placed in sleep mode for most of the time, so that its current drain reduces to just 11µA (maximum). It's awakened every 40ms for a short duration

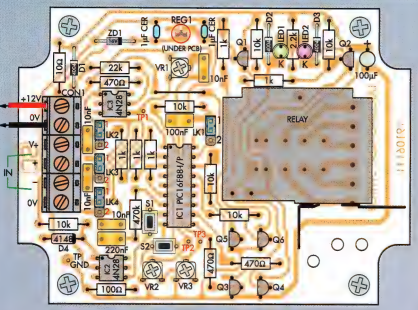
In addition, REG1 is a low quiescent power regulator that draws a mere 2µA. Further power savings are achieved by ensuring that IC1 applies voltage to trimpots VR2 and VR3 only at power up and when switch S2 (Reset) is pressed. These trimpots are used for setting the timer functions and are monitored by the AN6 and AN5 inputs of IC1. IC1 only needs to check these settings at power up as they do not change during operation.

When the reset switch is pressed,



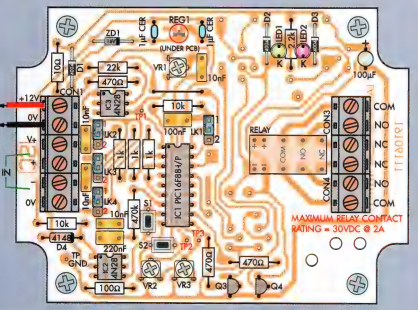
VERSATIMER / SWITCH

Fig.1: a PIC16F88-I/P microcontroller (IC1) is used to control the latching relay via switching transistors Q1-Q6 (or Q3 & Q4 only if a double-coil relay is used). IC1 also monitors the trigger input via optocoupler IC2 (ie, at its RB2 port), while other ports monitor the trimpot and link settings to set the edge triggering and relay modes, the timer and the power-up defaults. Optocoupler IC3 is included as a power saving measure – it turns on only when IC1's RA0 port goes high and applies voltage to VR1 so that the PIC microcontroller can monitor the input supply rail.



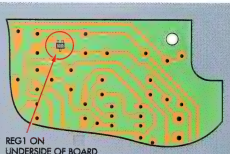
WIRED FOR SINGLE COIL LATCHING RELAY

Fig.2: this is the version to build if you want to switch the mains (230VAC). It uses a 12V 60A or 80A single-coil latching relay with the contacts on the side (see photo). Refer to Fig.5 for the mains wiring details.



WIRED FOR DOUBLE COIL LATCHING RELAY

Fig.3: this version uses the Jaycar SY-4060 double-coil latching relay which has contacts rated at 30VDC @ 2A. DO NOT use this version to switch the mains or other high voltages.



REG1 ON UNDERSIDE OF BOARD

Fig.4: regulator REG1 is a surface-mount device and is mounted on the underside of the PCB as shown here. You will need a fine-tipped soldering iron to install it – see text for details.

the RB3 pin, which is normally an input, is set as an output and it goes high to 5V for the time required to read the trimpot settings. When high, the circuit current is increased by 1mA.

Yet another power saving tactic involves preventing inputs RA3, RA4 & RB0 from floating if their respective link selections LK2, LK3 & LK4 do not have a link inserted. Any input that floats between 0V and 5V will cause that input to draw power. This is prevented by periodically driving these ports low for 500µs every 40ms. The 10nF capacitors keep the ports low between each drive period.

Relay driving options

If you are using a single-coil latching relay, it is driven using transistors Q1-Q6. For a double-coil relay, only transistors Q3 & Q4 are used and the other four transistors are omitted. In this case, the "+" sides of the relay coils are connected to the +11.4V supply and either Q3 or Q4 is switched on to drive the set or reset coil.

Diodes D2 and D3 quench the back-EMF voltage spike when the driven relay coil is switched off. D2 clamps the voltage when Q3 switches off and D3 clamps the voltage when Q4 switches off.

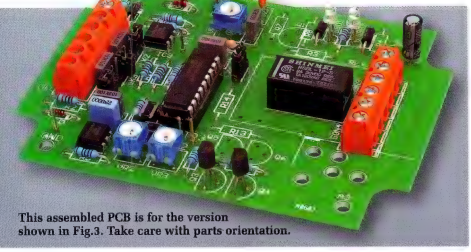
We need all six transistors to drive the single-coil latching relay because we need to change the connection polarity to the coil to provide the set and reset pulses. For one polarity, RB4 switches on transistor Q3 and this connects one side (X) of the coil to 0V while the other (Y) side of the coil is connected to +11.4V via transistor Q2 which is switched on by Q6 when RA6 goes high.

For the opposite polarity drive, Q4 is switched on by RB5 and Q1 is switched on via Q5 when RA7 goes high.

Diode D2 quenches the stored charge within the relay coil when Q3 is switched off and to ensure this diode fully shunts the current, transistor Q2 is kept conducting for sufficient time after Q3 is switched off. Similarly, when Q4 is switched off, transistor Q1 is kept conducting to allow D3 to fully clamp the voltage as the coil field collapses.

Link options

Link LK1 selects the set or reset polarity for the relay coil drive circuitry. This is necessary for the battery protection function, so that the relay disconnects the load if the voltage



This assembled PCB is for the version shown in Fig.3. Take care with parts orientation.

drops below the threshold voltage set by trimpot VR1. The adjustment procedure is described later in this article.

Links LK2-LK4 can be tied to the RA0 output (which can be high) or tied low to 0V. Alternatively, the associated inputs – RA3, RA4 & RB0 – can be left open circuit (ie, without a link).

IC1 checks whether or not a link is installed by first setting its RA0 output high. If a link has been installed between the "A" terminal and an input, that will then cause that input to go high. Conversely, if a link has been installed between an input and 0V, that input will go low. An input without a link connection can be driven both high and low.

Reading the input levels after driving the RA3, RA4 and RB0 pins high and low as outputs allows IC1 to determine which links are installed.

LEDs 1 & 2 indicate the relay switching. LED1 lights whenever transistor Q3 is switched on and LED2 lights whenever Q4 is switched on. The length of time each LED lights is set by the relay pulse length.

Construction

The VersaTimer/Switch is built on a PCB coded 19106111 and measuring 103 x 78mm. This fits neatly inside an IP65 polycarbonate case measuring 115 x 90 x 55mm, with the PCB secured to the integral stand-offs using M3 x 6mm screws.

Begin be checking that the PCB has the necessary corner cut-outs so that it fits into the box. It can be filed to shape if necessary using the PCB outline shape as a guide.

That done, check the PCB for any breaks in the tracks or shorts between tracks and pads. Check also that the hole sizes are correct by test fitting the larger parts (ie, the screw terminal blocks and relay). The corner mounting holes should be 3mm in diameter.

Note that two different versions can be built, each using a different relay. Both use 12VDC latching relays but these have different contact configurations and ratings. One relay is a double-coil type with 2A DPDT contacts (Jaycar SY-4060), while the other is a single-coil type with 60A or 80A 250VAC SPST contacts. Follow the correct overlay diagram for your particular relay.

The assembly is almost exactly the same for each version. However, the DPDT relay version uses less transistors and resistors compared to the SPST relay version.

Figs.2 & 3 shows the parts layout on the PCB for the two versions. Start the assembly by installing regulator REG1 on the underside of the board as shown in Fig.4. This surface-mount part can be easily installed by first using a pair of self-closing tweezers to hold it in place while one of its legs is soldered. That done, check that the component is positioned correctly over the mounting pads before soldering the remaining two pins.

Once REG1 is in position, flip the board over and install the single wire link. This goes in just below VR1 and you can either use 0.7mm diameter tinned copper wire or a 0Ω resistor.

The resistors are next on the list. Table 1 shows the resistor colour codes but you should also check each one using a digital multimeter before soldering it into position. Follow with diodes D1-D4 and zener diode ZD1, taking care to ensure that they are all correctly orientated.

Now for the transistors. Install Q1-Q6 for the single-coil relay version but note that only Q3 & Q4 are installed if you are using the double-coil relay. Take care to install the correct transistor type in each position and make sure that they are correctly orientated.

IC2 and IC3 can now be installed, along with an 18-pin socket for IC1. These parts must also be correctly orientated – see Figs.2 & 3. Leave

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	2/6	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	3/5	1kΩ	brown black red brown	brown black black brown brown
❑	3	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

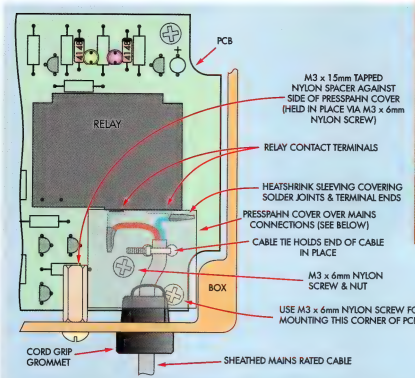


Fig.5: here's how to wire the version shown in Fig.2 to switch the mains. Make sure that the 2-wire mains cord is adequately rated for the job and that it is anchored to the case using a cordgrip grommet. You must also insulate the relay terminals with heatshrink and make a Presspahn cover (see below) to isolate the mains connections from the low-voltage circuitry.

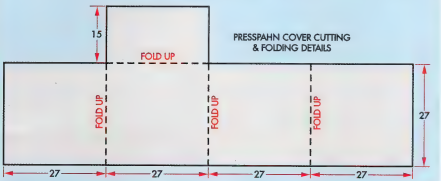
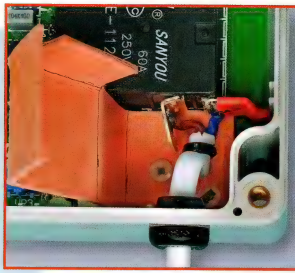


Fig.6: the Presspahn insulating cover is cut from a 108 x 42mm sheet and is folded to form a box, as shown here. You will need to drill holes in the righthand section to accept the Nylon securing screws and a cable tie.



This view shows how the mains wiring is installed. Insulate the relay terminals with heatshrink and be sure to use Nylon screws to secure the Presspahn cover. Heavy cable will be required to cope with high currents.

microcontroller IC1 out of its socket for the time being. It's installed later, after the power supply checks have been completed.

Follow with the capacitors and trimpots VR1-VR3. Make sure the electrolytic capacitor goes in the right way around and be careful not to get the trimpots mixed up. VR1 is a 20kΩ unit while the other two are 10kΩ types.

The 6-way screw terminal blocks are made up by dovetailing either two 3-way or three 2-way blocks together. These can be installed now, with their openings towards the adjacent edge of the board. Note that the second 6-way screw terminal block is only required for the DPDT relay version (Fig.3).

Installing the LEDs

The two LEDs are mounted so that the top of each LED is about 8mm above the PCB. This can be achieved by sliding a 3mm cardboard spacer between their leads when soldering them into position. Take care with their orientation – the anode lead of each LED is the longer of the two.

The 3-way headers for LK1-LK4 are simply snapped off a single in-line header strip. Install them in the positions shown but leave the jumper links off for the time being.

Finally, complete the PCB assembly by installing PC stakes at TP1, TP2, TP3 & TP GND, followed by switches S1 & S2. These miniature switches go in at the bottom left of IC1.

Mounting it in the case

Before fitting the PCB, you will need to drill holes in the case to accept the external leads. For mains switching, you will need to fit a cable gland at one end of the case (for the input trigger and supply leads) and a mains cordgrip grommet (to secure a mains lead) on one side of the case as shown in Fig.5.

If you are not switching mains voltages (ie, you are using the arrangement shown in Fig.3), then you will need to install cable glands at both ends of the case, in line with the centres of the screw terminal blocks.

Note that only the SPST 60A or 80A relay is suitable for switching mains voltages and this must be installed using the arrangement shown in Fig.2 and Fig.5. The 2A DPDT relay (Jaycar SY-4060) used in Fig.3 is not suitable for mains switching. In addition, the track spacing on the PCB is NOT suitable for mains voltages.

Mains switching

Fig.5 shows how to wire the unit to switch the mains. **However, do NOT attempt to do this unless you are experienced at working with high-voltage**

wiring and know exactly what you are doing.

Make sure also that the mains cable is adequately rated for the load current. Our prototype shows a light-duty 7.5A cable in place but you must use a heavier cable for higher currents.

A cordgrip grommet is used to secure the sheathed mains-rated cable to the box (for cables up to 10A). The hole for this grommet must be carefully sized and shaped so that the cord is clamped securely when the grommet is inserted into this hole.

That last step is critical – if the hole is too big, the cord will not be clamped securely.

As shown, the mains leads are soldered directly to the relay terminals and these must then be insulated using 10mm-diameter heatshrink sleeving. Do not bend the relay terminals as they are liable to break.

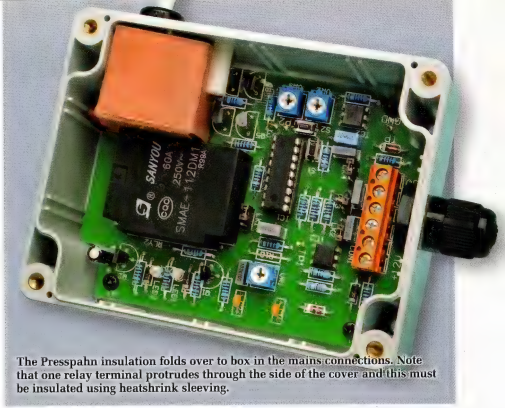
In addition, it's necessary to isolate this mains section from the low-voltage circuitry using a Presspahn cover. Fig.6 shows how to make this cover. It's cut out from a 108 x 42mm piece which is then folded as shown to make a box. Once it's made, you will need to drill holes in the righthand 27 x 27mm section to match the four 3mm holes (including the mounting hole) in the corner of the PCB.

That done, the Presspahn cover can be attached to the PCB using an M3 x 6mm Nylon screw and nut – see Fig.5. The mains lead is then secured to the PCB using a cable tie which loops down through two of the other holes.

Before finally installing the board in the case, it will also be necessary to connect the supply and trigger wiring to the 6-way screw terminal block. The PCB assembly can then be dropped into the case and secured using M3 x 6mm screws. **Note that you must use a Nylon screw for the corner hole that goes though the Presspahn (ie, the two screws used to secure the Presspahn material must both by Nylon types).**

Using Nylon screws ensures that the mains remains isolated from the low-voltage section of the PCB, even if one of the mains wires breaks away from its relay terminal and contacts one of these screws.

In addition, a Nylon screw and an M3 x 15mm tapped Nylon spacer is attached to the side of the box, directly above transistors Q4 & Q6. This holds the side of the Presspahn material in place and ensures that it remains in position when it's folded over to form a box and the lid attached. It also stops the Presspahn from bending and damaging the transistors.



The Presspahn insulation folds over to box in the mains connections. Note that one relay terminal protrudes through the side of the cover and this must be insulated using heatshrink sleeving.

Complete the assembly by fitting the front panel label. It can be downloaded in PDF format from the SILICON CHIP website.

Setting up

With IC1 out of circuit, apply power (eg, from a 12V battery) to the +12V and 0V inputs and check the voltage between pin 14 of IC1's socket and TP GND. This should be very close to 5V, ie, between 4.98V and 5.02V. If this is correct, switch off and insert IC1 into its socket, taking care to orientate it correctly.

Now measure the supply voltage applied to the circuit at the +12V input. Using a calculator, divide this voltage by three.

Next, use your DMM to monitor the voltage between TP1 and TP GND and press switch S2. Adjust VR1 so that the DMM reads the supply voltage divided by three value, as calculated above (eg, if the supply voltage measures 12.3V, adjust VR1 to give 4.1V between TP1 and TP GND).

This adjustment sets the low-battery switch-off value to 11.5V, with the circuit then remaining in standby until the battery voltage rises to 12V. The actual voltages measured by IC1 are 3.83V for the low battery switch-off and 4V for the relay return voltage.

This setting can be changed if a different low-battery switch-off voltage is required. The required voltage at TP1 is calculated simply by first dividing the required low-battery switch-off voltage by 3.83V. This value then becomes the divisor for the input supply voltage and the resulting divided value becomes the voltage setting for TP1.

For example, let's say that the required low-battery switch-off voltage is 11V. In this case, 11V divided by 3.83 = 2.87. If the battery voltage is exactly 12V, we simply divide this by 2.87 to get 4.18V. This voltage is then set at TP1 using trimpot VR1.

The switch-on (ie, resume) voltage after a low voltage has been detected is now the 4V return voltage multiplied by 2.87. This gives 11.48V.

Relay pulse duration

Trimpot VR2 sets the pulse duration for the relay. In practice, this can be set anywhere from 0-500ms, with 1V on VR2's wiper giving 100ms (ie, divide the voltage reading by 10).

To carry out this adjustment, connect a DMM between TP2 and TP GND and press S2. It's then just a matter of adjusting VR2 to set the recommended pulse duration for the relay.

For the Jaycar SY-4060, the pulse duration required is about 25ms, so VR2 is set to give 250mV on TP2. For the 60A and 80A relays, the pulse

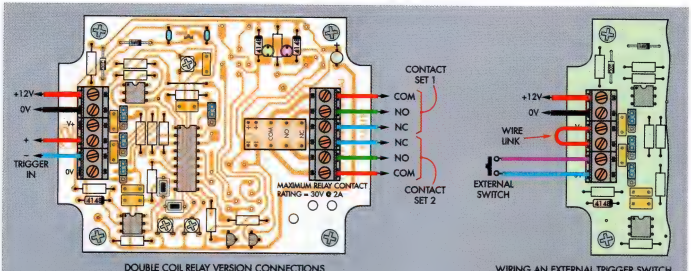


Fig.7: this diagram shows the external connections to the double-coil relay version. It's suitable for switching low voltages only (up to 30VDC @ 2A).

Fig.8: here's how to wire an external trigger switch (both versions).

needs to be equal to or greater than 60ms which means that VR2 should be set to give at least 600mV.

Setting the links

LINK LK1: LK1 sets the relay state when the battery is low. Generally, this is set so that the relay's NO and COM contacts open when the low-battery cut-out point is reached, to remove battery power from the load. This is done by installing LK1 in position 2.

If you use a different relay to the types specified, then LK1 may need to be placed in position 1 to achieve the same result, ie, so that the contacts are open on low battery.

You can ensure that LK1 is correct by checking that the relay's contacts open when the supply is reduced below 11.5V or if VR1 is adjusted fully anticlockwise. You will need to wait about 10s for the low-battery voltage to be detected and the relay switched. Be sure to readjust VR1 to its correct position after checking this operation, as described previously.

LED1 lights briefly when the relay contacts close, while LED2 lights briefly when they open. This assumes that you are using one of the specified relays and that LK1 is in position 2. The operation of the LEDs is reversed if LK1 is placed in position 1.

LINK LK2: LK2 sets the input trigger edge level. With LK2 in position 2, the relay is triggered when the input signal drops from a high level to 0V (ie, a falling edge trigger). In position 1, the relay triggers on a rising input signal, eg from 0V to 5V (or similar).

If LK2 is left out, the relay triggers

Table 3: Link Settings & Trimpot Adjustments

Link Setting	Position 1	Position 2	Open	Notes
LK1 Low Battery State	NO contacts closed on low battery	NO contacts open on low battery	Not used	Relay contact state with low battery
LK2 Edge Triggering	Triggers on high-going input & when S1 closes	Triggers on low-going input & when S1 opens	Triggers on both edges and when S1 closes or opens	
LK3 Operation	Momentary with timer	Toggle (or alternate)	Follow input	
LK4 with LK3 set for Timer Mode	0-5h	0-50s	0-5m	VR2 sets value
LK4 with LK3 set for Toggle Mode	Powers up with NO contacts closed	Powers up with NO contacts open	Not used	Power up relay state

Adjustments	Use	
VR1	Sets low battery switching voltage	TP1 monitors divided battery voltage with S2 pressed
VR2	Relay pulse duration 0-500ms	TP2 monitors VR2 setting with S2 pressed
VR3	Timer value	TP3 monitors VR3 setting with S2 pressed
S1	Test operation	
S2	Resets timer and sets changed links and adjustments	Press whenever links or adjustments are made
S2	Press and hold at power up to change timer relay state	Selects either NO contact closed with timer or NO contact open with timer

on both rising and falling edges.

LINK LK3: LK3 sets the relay operation to either Momentary mode (position 1), Toggle mode (position 2) or Follow mode (no link).

The Momentary mode operates with a timer. Once triggered, the relay switches on for the timer duration and then turns off again. By contrast, in Toggle mode, the relay changes state on each trigger signal. Once triggered, it remains in that state until the next trigger signal arrives.

The Follow mode allows the unit to be used as a replacement for a standard relay. It duplicates the operation of a standard (non-latching) relay.

LINK LK4: LK4 sets the timer range for the Momentary mode. LK4 in position 1 gives a range of 0-5 hours, position 2 gives 0-50 seconds and no link gives 0-5 minutes.

The exact time-out value is set by trimpot VR3. For the 0-50s range (position 2), 1V at TP3 (with S2 pressed) gives 10s, 2V gives 20s and so on, up to 5V which gives 50s. Other voltages give corresponding timeout values, eg, 0.5V gives 5s and 2.5V gives 25s.

Similarly, for the 0-5 hour range (position 1), 1V at TP3 is equivalent to 1 hour and for the 0-5 minute range (LK4 not installed), 1V at TP3 is equivalent to 1 minute.

Switch S2 can be used to cancel (or reset) the time-out during timing. Any retriggering during timing will be ignored.

By default, the unit is set so that during timing, the relay's NO contact is closed. This means that the NO contacts are normally open at power up and after time-out.

However, this can be changed so that the relay's NO contact is closed at power up and open during timing. To do this, press and hold S2 for 5s during power up and the option will be set. Repeat this procedure to revert to the default mode.

Link LK4 can also be used when the unit is set to Toggle mode (LK3 in position 2), to select the relay state at power-up. Installing LK4 in position 1 sets the NO contacts closed at power-up, while position 2 sets the NO contacts open at power-up. LK4 has no effect in the Follow mode.

Test switch

Test switch S1 allows you to easily check the results of the above link settings. It simply allows you to manually trigger the unit, so that you can test the unit without having to feed in an external trigger signal.

LEDs1 & 2 indicate the relay operation. As stated, LED1 briefly lights when the relay contacts close, while LED2 briefly lights when they open.

Triggering input

The IN+ and IN– inputs are used to trigger the VersaTimer/Switch. The maximum trigger voltage is 35V and the minimum is 3.25V if the 10kΩ resistor used for R1. The trigger signal must be capable of delivering about 400μA with a 5V supply.

Note that R1 should be changed to 6.2kΩ for a 3V trigger input, 3kΩ for a 2V trigger input and 1.5kΩ for a 1.5V trigger input.

Note also that the triggering input is electrically isolated so that a voltage that is not referenced to the VersaTimer/Switch circuit can be used as

Parts List

1 PCB, code 19106111, 103 x 78mm
1 115 x 90 x 55mm IP65 polycarbonate enclosure
1 12VDC latching relay (see below)
1 DIP18 IC socket
2 3-6.5mm diameter cable IP65 cable glands
2 3-way PC-mount screw terminal blocks, 5.08mm spacing
1 12-pin SIL pin header with 2.54mm spacings (broken into 4 x 3-way headers)
4 2.54mm pin spacing jumper plugs
2 momentary pushbutton 2-pin PC mount switches (S1,S2)
4 M3 x 6mm screws
4 PC stakes
1 20kΩ miniature horizontal trimpot (VR1)
2 10kΩ miniature horizontal trimpots (VR2,VR3)

Semiconductors
1 PIC16F88-I/P microcontroller (IC1) programmed with 1910611A.hex
2 4N28 optocouplers (IC2,IC3)
1 MCP1703T-5002E/CB 250mA 5V low-dropout low-quiescent current regulator (REG1)
2 BC337 NPN transistors (Q3,Q4)
1 3mm green LED (LED1)
1 3mm red LED (LED2)
3 1N4004 1A diodes (D1-D3)
1 1N4148 signal diode (D4)
1 16V 1W zener diode (ZD1)

Capacitors
1 100μF 16V PC electrolytic
2 1μF monolithic ceramic
1 220nF MKT polyester
1 100nF MKT polyester
4 10nF MKT polyester

Resistors (0.25W 1%)

1 470kΩ	3 1kΩ
1 22kΩ	3 470Ω
2 10kΩ	1 100Ω
1 2.2kΩ	1 10Ω

Additional parts for 30V 2A DPDT version
1 12VDC DPDT 2A @ 30VDC latching relay (Jaycar SY-4060)
2 3-way PC-mount screw terminal blocks, 5.08mm spacing

Additional parts for 250VAC 60A or 80A SPST version
1 12V SPST 80A @ 250VAC latching relay [Oatley Electronics JMX-94F-A-Z (www.oatleyelectronics.com)]
Or
1 12V SPST 60A @ 250VAC latching relay [Virtual-village (www.virtual-village.com.au) or see www.virtual-village.com.au/4-x-12v-coil-polarized-latching-relays-60a-250v-ac-003602-027.html]
2 BC327 PNP transistors (Q1,Q2)
2 BC547 NPN transistors (Q5,Q6)
4 10kΩ 0.25W 1% resistors
2 1kΩ 0.25W 1% resistors

Additional parts for for mains control switching
1 108 x 42mm Presspahn sheet
2 M3 x 6mm Nylon screws
1 M3 x 15mm Nylon screw
1 M3 tapped Nylon standoff 15mm long
1 M3 nut
1 cord grip grommet to suit the sheathed mains cable
1 100mm cable tie

Latching Relays: How They Work

The most common relay is the standard non-latching type. This comprises a relay coil, an armature and switch contacts as shown in Fig.9(a).

When no current flows through the coil, the relay contacts are held in their normal position by spring tension, with the NC (normally closed) contact resting against the COM (common) contact and the normally open (NO) contact left open.

Conversely, when the relay is powered, the current through the coil causes the armature to be attracted to the coil's pole piece and this moves the relay contacts to their opposite position. As a result, the COM contact closes against the NO contact and the NC contact opens.

Fig.9(b) shows how a standard non-latching relay can be driven using a switch. The switch (S1) simply connects power to the coil when it is closed.

Another arrangement for the non-latching relay is when the common (COM) and normally open (NO) contacts are used together with a momentary contact switch to form a self-latching operation – see Fig.9(c). Pressing the pushbutton switch (S1) activates the relay and closes the NO and COM contacts. These contacts now form a parallel connection across S1 so that when S1 is opened, the relay coil remains energised.

These closed contacts (or other contacts) can also be used to power external circuitry. Note, however, that this self-latching relay circuit is not the same as a latching-type relay, since the relay continues to draw coil current.

Latching relay

A latching relay differs from a standard (non-latching) relay in that it will remain in either state (or latch) without further power. In some ways, this is analogous to a conventional household light switch – when the switch is flicked to one position, it remains there until the actuator (or switch lever) is switched back to its alternative position. However, instead of the switch lever, a latching relay uses a coil and an armature to activate the switching action.

Fig.10(a) shows the internal construction of a latching relay. It includes two horseshoe-shaped bar magnets which are positioned between the C-shaped core (or pole pieces) of the relay coil. These two bar magnets are physically separated and attached to a pivot which allows the assembly to rotate clockwise and anticlockwise between the C-core.

This pivoting assembly is called the "armature". When the armature is in its anticlockwise position, the top bar magnet's south pole is attracted to the top section of the currently non-magnetised C-core (or pole piece), while the bottom bar magnet's north pole is attracted to the lower section. As a result, the armature is held in that position.

Note that the bar magnets can be horseshoe shaped as shown in Fig.10(a) or they can be two straight bars with north on one face and south on the other.

The latching relay depicted in Fig.10(a) is activated by applying a voltage to the coil, so that the current flows in a direction that causes the top of the C-core to become a south pole and the bottom to become a north pole. When that happens, the like south poles at the top and the like north poles at the bottom are repelled from each other.

At the same time, the south pole at the top of the C-core attracts the north pole of the top magnet, while the north pole at the bottom of the C-core attracts the south pole of the bottom armature magnet. As a result, the armature rotates clockwise to the position shown in Fig.10(b).

The armature now remains (or latches) in this position, even after coil current is removed. That's because the north pole at the top of the armature is still attracted to the C-core (which becomes non-magnetised when the coil current ceases). Similarly, the south pole at the bottom of the armature is attracted to bottom pole piece of the now non-magnetised C-core.

Flipping back

Getting the relay to latch back into its previous position simply involves feeding a

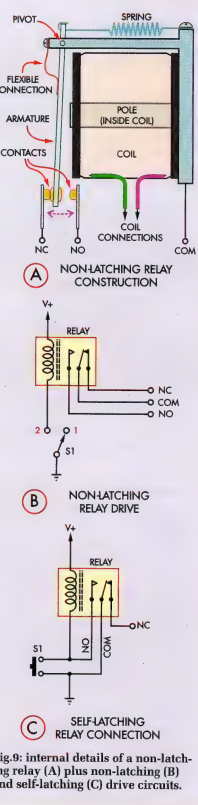


Fig.9: internal details of a non-latching relay (A) plus non-latching (B) and self-latching (C) drive circuits.

a trigger. The voltage differential between the trigger source and the Versa-timer/Switch circuit should limited to a maximum of 50V.

The triggering sensitivity is quite good. In fact, the unit can be triggered by connecting the input across an indicator LED in an external device (ie, it will trigger when the LED lights). Note, however, that R1 should be reduced to either 3kΩ or 1.5kΩ to ensure reliable triggering in this situation.

Finally, connect the inputs as shown in Fig.8 if you want to trigger the unit using an external pushbutton switch. Note that the switch current adds to the battery drain while it is pressed and is 1.1mA at 12V. SC

current pulse through the coil in the opposite direction. This forces the top pole piece to become a north pole and the bottom pole piece to become a south pole. As a result, the armature rotates anti-clockwise, back to the position shown in Fig.10(a)

Note that the current direction through the coil must be correct in order to get the relay to change state. If it isn't, the armature remains in its present position.

Note also that the north and south markings for the pole pieces in Figs.10(a) & 10(b) are those that would cause the armature to rotate to the position shown. However, as stated, these poles become non-magnetised when coil current ceases. In practice, the coil current is only required for a brief period in order to move the armature to its alternative position. The current pulse can be as short as 5ms for small relays and about 60ms for larger relays.

It's both undesirable and unnecessary to have the coil energised permanently. Prolonged magnetisation of the pole pieces can cause them to become permanently magnetised (called "remanent magnetism"). When this happens, the latching action is less effective in one position (ie, where the remanent magnetism repels the attracted pole after power is removed).

This also reduces the current rating of the contacts due to reduced contact pressure.

As shown, the armature of the latching relay drives a lever and this in turn opens and closes the contacts. The accompanying photos also show a latching relay with the armature in its alternative positions.

Latching relay variations

Latching relays come in two different types: single coil and double coil.

As stated, the single coil latching relay changes state depending on the polarity of the voltage applied to the coil. By contrast, a double-coil type relay uses one coil to set the contacts one way and another coil to reset them back the other way.

The advantage of the double-coil relay is that fewer components are required to drive it. Fig.11(a) shows how a single-coil latching relay can be driven using a DP3P switch. In position 1, the top of the coil is at ground and the lower end of the coil is connected to the positive supply. This causes the relay to be in its reset state, with the NO contact open and the NC contact shorted to the COM contact.

In position 2, no current flows to the coil while in position 3, the coil current is reversed and the relay switches to the set position. As a result, the COM contact closes against the NO contact and the NC contact is now open.

Fig.11(b) shows the simpler switching arrangement that's used for a double-coil latching relay. In this case, the relay can be controlled using a SP3P switch, with one coil driven with the switch in position 1 and the other coil driven in position 3.

Finally, note that the traditional NO and NC nomenclature does not really apply for latching relays. However, the relay manufacturers still generally indicate NO and NC contacts and qualify these states as valid when a certain current polarity is applied to one of the coils. SC

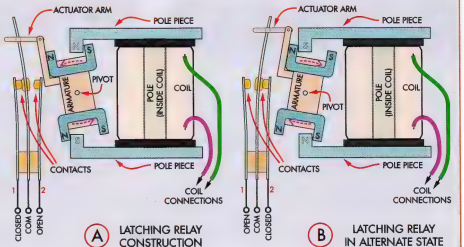
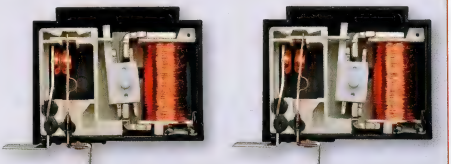


Fig.10: how a latching relay works. It uses magnets at either end of a moving armature which are attracted/repelled by the polepieces, depending on the direction of the current pulse applied to the coil.



These inside photos show the two armature positions inside a single-coil latching relay. The armature remains in its last position until the next current pulse is applied to the coil (ie, it self-latches).

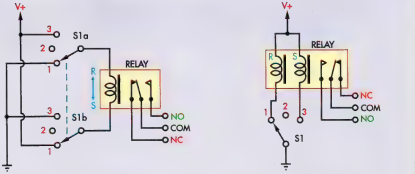


Fig.11: a single-coil latching relay (A) can be driven using a DP3P switch. The switching for a double-coil latching relay is somewhat simpler since only a SP3P switch is required. No current flows through the coil(s) in position 2.

Marantz CD6003 CD

...high quality machine has pitch control and USB inpu

Marantz is one of the few mainstream hifi manufacturers still making dedicated CD players. In fact, they make quite a few, ranging in price from affordable to very expensive. We take a look at a machine which is somewhere in-between, offering pitch control and a USB input so MP3 and other files can be played.

These days, most people happily play their CDs through a DVD player, which might be a run-of-the-mill model or a Blu-ray player. And while the better DVD players do give a reasonable performance when playing CDs, it is certainly not the best sonic result and there are often problems with hum and other interference.

It may surprise some readers just how much RF interference can be superimposed on the analog audio and video output of DVD players, particularly on the cheaper models. Sometimes this can be enough to severely interfere with AM and FM radio reception.

So inevitably, using a DVD player for CDs means that you can be feeding significant RF signals into the inputs of your amplifier. That is bad enough but the fact that just about all DVD players are of double-insulated construction and use a switchmode power supply means that there can be significant buzz, hum and other extraneous noises to mar your enjoyment of the music.

We investigated these problems fairly thoroughly in the October 2007 issue of SILICON CHIP.

One way to circumvent most of the problems of DVD players is to feed the TOSLINK (optical) digital output to the digital input on a home theatre receiver but even there, the results might not be optimum. Better still is to feed the TOSLINK output to a high-quality digital-to-analog converter (DAC) and to that end, we published a high-performance

player

Review by Leo Simpson

DAC in the September to November 2009 issues of SILICON CHIP. This had the added feature of remote control of the volume level.

Well, that solves most of the issues to do with sound quality but DVD players still have drawbacks. For example, they often take an age to power up and then recognise that they have loaded a CD. And since they tend to be designed with on-screen display of their features, they don't do a good job of indicating CD tracks and other functions.

And then, when you press PLAY or change tracks, they often have to cogitate about it for a while before responding to your command.

All of this came to mind just recently when I decided I wanted a new CD player for my study. Having made the decision, I was immediately confronted by the limited choice on offer – just a few well-known brands and at prices considerably higher than even for a good quality Blu-ray player.

Features:

- ***Pure high-quality CD Player with MP3, WMA and WAV playback***
- ***CD-R/RW compatible; CD-text***
- ***HDAM-SA2 circuitry***
- ***High-quality D/A conversion (CS4398)***
- ***Customised audio components***
- ***Quick replay***
- ***Pitch control***
- ***iPod-compatible USB input***
- ***Coax and optical digital outputs***
- ***Headphone output with level control***
- ***Dedicated remote control***

But I also wanted a high-quality player with the facility of pitch control and that limits choice even further. Sure, there are some reasonably priced "professional" CD players with pitch control but these are geared more to installations in clubs and other similar venues and their audio performance is not up there with the high-quality audiophile brands.

Which brought me to the Marantz CD5004. This is their "entry-level" player which does have pitch control, along with the capability to play CD-Rs, and CD-RWs and it will play CD-DA (PCM) alongside MP3 and WMA formatted files at 42, 44.1 and 48kHz sampling frequencies. As well, it has the ability to read music data on MP3s and WMA files as well as text-data encoded CDs. This means that it will show the title of each CD track as it begins playing.

It also uses the Cirrus Logic CS4392 DAC chip and the HDAM-SA2, the company's proprietary Hyper Dynamic Amplifier Modules which were originally developed for their premium Reference Series products. This means that its audio performance should be very respectable. So I checked prices and some on-line reviews, all of which were encouraging.

But then I considered the next machine up in the range, the CD6003. It uses a better DAC, the Cirrus Logic CS4398 and it also has a USB socket on the front panel which means that you can plug in a flash drive, iPod or other media source so you can get a really good result when playing these files. In all other respects, it appears quite similar in features to the CD5004.

Indeed, all the Marantz CD players have the same styling and general presentation with the differences being mainly confined to the internal circuitry and possibly the ability to play SACD disks.

Some of the more up-market models in the range have been specially tweaked by the noted audiophile designer, Ken Ishiwata but I think he has had a hand in the design of most of the Marantz range. He really knows his stuff.

So I decided to purchase the Marantz CD6003; just like that, sight unseen. When it was delivered, I wanted to see just how good it was, so I put the CD6003 through its paces on our Audio Precision test gear.

And that is how this review came into being.

Inside the Marantz 6003; it's as complex as we have ever seen in a CD player, with no less than seven PCBs. But beware of that unshielded mains input socket (left top) – it's a trap for the unwary (if you ever open the case, that is!).

Presentation

The first aspect of the Marantz CD6003 which impresses is that it is such a substantial machine, in great contrast to the often flimsy cases and ever-diminishing scale of most DVD players. Marantz gear is bulky and solid; there is no other way to say it.

And while you can have it in ubiquitous black, I much prefer the silvery sheen shown in the accompanying photos. The front panel looks to be all metal but the central section is an aluminium extrusion while the curved sections on either side are substantial plastic mouldings.

Overall dimensions are 435mm wide, 104mm high and 340mm deep, including mounting feet, the front panel headphone knob and rear-mounted RCA phono sockets. Weight is a hefty 6.6kg.

The disk drawer is centrally mounted above the dot matrix display. To the left of this are three pushbuttons (Open/Close, Fast Forward, Fast Reverse), the USB socket and a tiny pushbutton which selects between USB and disk. To the left of those again is a large button for the power switch.

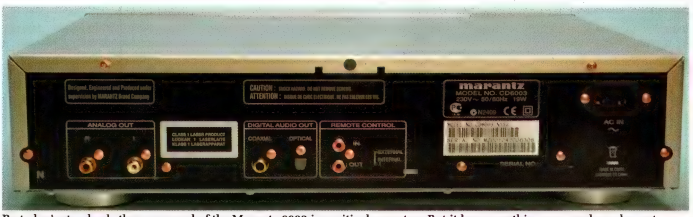
To the right of the display panel are another three pushbuttons (Play, Stop & Pause), the 6.5mm headphone socket and the associated small knob for its volume level.

On the rear panel is the 2-pin IEC socket for power, a pair of gold-plated RCA phono sockets for the left and right analog outputs plus another gold-plated RCA socket for the coaxial (SPDIF) digital output, a TOSLINK output socket and a further two RCA sockets for the Marantz proprietary remote control system which allows the CD player to be tied to other Marantz equipment.

There is also a small slide switch to select between the player's infrared remote control and an external control from other Marantz equipment (eg, amplifier or home-theatre receiver).

The CD6003 is double-insulated, hence the 2-pin IEC power socket which accepts a standard 3-pin IEC power cord. However, the machine does not use a switchmode power supply. Instead, as becomes apparent when the top cover is removed, it uses a rather elaborate conventional linear power supply with two mains transformers, one of which is tiny, to provide the standby function.

Inside, the Marantz appears to be far more complex than any previous CD player we have reviewed. No less than seven PCBs are employed. On the lefthand side of the chassis is the very large power supply board, with umpteen (well, five) regulators fitted with heatsinks.



By today's standards the rear panel of the Marantz 6003 is positively spartan. But it has everything you need: analog out, digital audio out in both coaxial and optical (TOSLINK), provision for a wired remote control and finally, a 2-pin IEC mains socket (which fits the standard 3-pin IEC mains plug but does not have an earth pin because the unit is double insulated).

Interestingly, when the unit is on standby, a minuscule red LED on the front panel is alight. Pressing the Power button closes a relay on the power PCB and switches over to the main supply. This extinguishes the red LED and lights up the dot matrix readout which momentarily displays "Power On" then "TOC reading" (indicating that it is attempting to read the table of contents on the CD). If none is present, it then says "No disc". It then displays "CD" to indicate that it is ready for you to load a CD. Clever little blighter, isn't it?

But it is quicker to respond than a typical DVD player which can seemingly take weeks to rouse itself when it is powered up.

Power consumption is quoted as 19W, dropping to a minuscule 300mW in standby mode.

Looking back inside the chassis again, we were a little surprised to see that the AC terminals on the IEC power socket were bare of any insulation. Shock, horror! Now I know that the back panel carries the Caution notice "Shock hazard. Do not remove screws" (or in French: "Attention: risque de choc electrique. Ne pas enlever les vis" – nowhere near as threatening) but those terminals should still have some protection from the fingers or tools of a technician who may not be concentrating.

Incidentally, the same comments apply to the copper side of the PCB which carries the terminals of the mains transformer.

The centrally located PCB carries the NEC microprocessor which controls the transport mechanism, all the play functions and provides the digital outputs. The large PCB on the righthand side of the chassis is the aforementioned HDAM SA2 "Hyper Dynamic Amplifier Modules". These are operational amplifiers designed with discrete transistors; not any of those "ghastly" op amp ICs!

This comes from Marantz's deliberate appeal to the (often screw-ball) audiophile end of the market which tends to regard even the best op amp ICs with disdain. Not that Marantz is wrong to take this approach since it is definitely possible to get better performance from a discrete design than even the best op amps.

Underneath that same PCB is the surface-mount Cirrus Logic CS4398 DAC chip. Presumably, audiophiles will tolerate that; after all, you must have a DAC and if it was a discrete design it would be huge.

Also of interest is the separate headphone drive amplifier which appears to be based on a surface-mount dual op amp. This is a so-called "current buffer" which provides a low impedance drive to the headphones.

All told, the standard of construction is very good with the double-thickness base plate providing extra rigidity.

The CD6003 comes with a large infrared remote control and you might wonder why so many buttons are needed; there are no less than 41! Funnily enough, each one has a function but as we subsequently found, some of those could have been arranged differently.

Operating it

Using the Marantz CD6003 is a dream compared to the average DVD player, in that it responds much more quickly, as mentioned above. It powers up quickly and if you place a CD on the tray and press the Load/Eject button, it immediately retracts the drawer and then reads the disk's table of contents, giving a message on the readout "TOC Reading", followed by the number of tracks and the total playing time. That takes about 10 seconds; a bit slow for a CD player but at least you know that the machine is actually doing something rather than seemingly confused, as seems to happen when a CD is fed into a DVD player.

Pressing Play or selecting a track number with the remote control starts playing that track within two seconds. Indeed, anything you do with the remote elicits a response within one or two seconds.

By the way, the player can cope with any number of tracks up to 99. Some CD and DVD players are very limited in this respect.

If you want to find a particular track on a CD, you just press "AMS" and this plays 10 seconds of music from each track, in succession. When you find the track you want, you just press Play to continue.

And of course, you can play the tracks in random fashion, repeat sections, tracks or the whole disk. Or you can program the order, delete some tracks and various other functions which most users will probably ignore.

EX playing modes

Audiophiles can be very "thingy" about CD players and their various functions and one of the things they have apparently learnt is that the internal microprocessor and display readout and even the digital outputs can degrade the analog audio output on CD players.

This is true for some audio equipment and Marantz, seek-

ing to keep these fanatics (er, audiophiles) happy, gives the user the option to turn off the digital outputs and the display, using the Sound Mode button.

And interestingly, various reviewers have noted that the sound quality improves noticeably. Well, that is balderdash, to put it politely. Our tests show that it makes not one iota of difference – not even a poofteenth of a percent.

In fact, the only difference we could detect when "Audio EX" mode is selected (which kills the digital outputs and the display during playback) was that it prevented some remote control functions, such as selecting the next track with the "next track" button.

As already noted, the CD6003 provides pitch control and this can be incremented or decremented in steps of 1% to a maximum of ±12% by pressing the appropriate buttons on the remote.

Annoyingly, this kills the digital outputs and these can only be re-enabled by pressing the Reset button to kill the pitch variation. So what if you want to listen to the Marantz with pitch control and via the digital output to a home-theatre receiver?

Too bad – Marantz won't let you and yet it is possible.

More annoying still is that the remote has buttons for volume control but you can only have that feature if you have the player linked to a Marantz integrated amplifier.

Now this is really silly since the Cirrus CS4398 DAC is set up for digital remote control and would give a higher quality result than when the analog outputs are connected to a Marantz amplifier with its own remote control of volume.

While we're in complaint mode, we should also note that any playback from USB flash drive etc is only available from the analog outputs of the player; so no digital output.

So again, if you want to listen to music files on your flash drive via TOSLINK/SPDIF to your home-theatre receiver, you will have to find another way.

The good stuff. . .

Having got those complaints out of the way, we can talk about the good stuff – and there is plenty of it!

One point we have noticed about good-quality CD players is that they typically cite their frequency response as 2Hz to 20kHz but with no tolerance limits. The Marantz CD6003 is the same. And typically, CD test discs do not put out frequencies below 20Hz. So what is the frequency response of the CD6003?

To answer this question, we produced our own test CD, with sinewave signals down to 1Hz. And how far down was the response at 1Hz? 0dB. In other words, it is ruler flat down to almost DC. Incredible.

At the high end though, it starts to roll off very slightly above 10kHz and is -0.6dB down at 20kHz. We would have preferred considerably less roll-off; say no more than -0.2dB.

Where the Marantz CD6003 really shines is in its figures for total harmonic distortion. This is quoted at .002% at 1kHz, a typical CD player spec.

We measured around .0015% at 1kHz but we also found that it varied very little from that figure over the whole frequency range from 20Hz to 20kHz. Not that we could easily measure that performance on the Audio Precision because of the necessity to change filter bandwidths (22kHz, 30kHz and 80kHz) depending on the frequency being measured.

Not only that but the Marantz does have some residual switching artefacts in its analog outputs at a level of -60dB.

However, we managed to get meaningful harmonic distortion figures by using the averaging mode on the Agilent DSO7304A digital scope to remove high frequency noise and switching artefacts.

At lower signal levels of -30dB and below, the Marantz is similarly outstanding. For example, at 1kHz and -30dB, the THD is .04% with a filter bandwidth of 22Hz to 22kHz. At -40dB it degrades to about 0.14%; still an impressive result.

Baffling!

To say that we were impressed with the harmonic distortion performance is understating the case. It is so good we were baffled. It is better than the specs for the Cirrus CD4398 when handing 16-bit PCM signals.

Which raised the question: is Marantz converting the data stream off the disk to 24-bit to get the higher performance which is then possible from this DAC? Possibly but we did not have time to investigate this point.

Clearly, in terms of overall distortion performance, this is the best CD player we have tested.

Linearity of the DAC was good but not the best we have tested. There is no error down to -80dB but at -90db, it produced -88.5B at 1kHz; an error of +1.5dB.

By the way, this measurement was done via the Audio Precision passive audio brickwall filter so no sampling artefacts would have degraded this measurement.

We also checked signal-to-noise ratio and channel separation. For S/N ratio we measured -103dB unweighted (22Hz to 22kHz) and 110dB A-weighted.

The reason for the improvement with A-weighting is that there is a very low residual level of hum in the outputs; A-weighting filters that out.

Separation between channels is quoted as -100dB, with no frequency limits. We measured typically -102dB across the spectrum; reducing slightly to -99dB at 20kHz, an excellent figure.

Finally, we decided to test the front panel headphone output which has its own volume control. This has a quoted maximum output level of 18mW into 32-ohm headphones but no other specs.

Since we have recently been designing a high-quality stereo headphone amplifier, we just happened to have a suitable set-up for testing into various loads; very convenient.

Suffice to say that the headphone amplifier appears to be not quite up to the same very high standard as the rest of the player. But it is still very respectable and has adequate drive for headphones of various impedances and sensitivity.

THD is around the .002% mark while the S/N ratio is -104dB; a smidgen better than the main analog outputs. Separation between channels was around -75dB and channel matching about 1dB; mainly a function of resistor tolerances and the miniature ganged volume control.

In use?

The Marantz performs impeccably. The transport mechanism is very smooth and always quiet – a pleasure to use. And the sound quality is very high – no complaints at all. It is certainly a high-quality machine.

Recommended retail price is $899. For further information, contact your hifi retailer or the Australian distributor for Marantz products: Qualifi Pty Ltd, 24 Lionel Road, Mt Waverley, Vic 3149. Phone (03) 8542 1111. Website: www.qualifi.com.au

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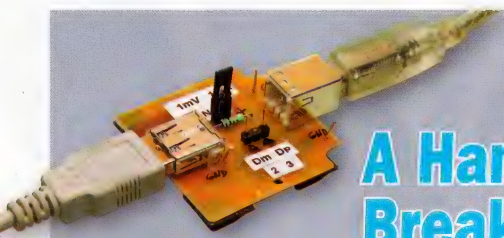


By JIM ROWE

A Handy USB Breakout Box

You can build it in 10 minutes and for less than $15

USB is a great interface but it is isn't foolproof. The good thing is that you can troubleshoot it with this simple USB "breakout box". It connects into virtually any USB 1.1 or USB 2.0 cable and lets you examine D+ and D- signal line activity with your scope – as well as letting you check the USB power line voltage (Vbus) and even the current being drawn from the bus.

RECENTLY, I'VE BEEN working on the development of a USB device, ie, a device designed to hook up to a PC via a USB cable and become a "bus powered peripheral". Along the way, I realised that I was going to have to measure the current drawn by the device, to make sure it conformed to the USB specification. Since I also struck trouble getting the device to "enumerate" properly when it was first hooked up to a PC, it was also going to be handy to be able to check the voltage levels on the two USB signal lines with my scope, to see if the voltage levels were within specification.

Now since the device's USB connector was mounted directly on its PCB, the only way to measure the current drawn from the host via the USB bus would be to cut the pin 1 track on the board, so I could connect in a milliammeter. But I didn't want to cut a track on the board just for this test, because it would need to be bridged again with a short length of wire afterwards.

It also turned out to be a bit tricky connecting my scope's probes to the two USB signal lines, because my board was fairly small, with a high component density near the USB socket. In fact, this is always the way with USB interfaces – they're hard to get at.

What I really needed was a small "breakout box" which could be connected in series with the USB cable between the PC and the device. This would make any of the bus lines available for testing. So I knocked one up using a small piece of PCB cut from an old prototype board. The latter already had a USB type-A socket mounted on it, so all I had to do was add a type-B socket and a handful of other parts. It looked a bit untidy (as you can see from the above photo) but it worked well and let me do the testing in short order.

When I mentioned that I had built up this handy little USB testing jig to SILICON CHIP's esteemed publisher Leo Simpson, his response was as quick as a shot: "If it's that handy why don't you take a quick picture of it and draw up the circuit, so we can publish the details in the magazine and give other people the chance to build one?"

In the end, as well as taking a few photos and drawing up the circuit, I also designed a PCB pattern for it. So when you build one, it will look better than my prototype. What's more, it will take take just 10 minutes or less to put together.

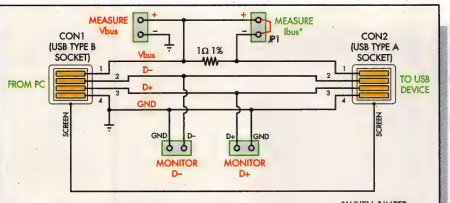
Circuit details

Fig.1 shows the circuit and there really is very little to it. All four USB lines basically pass "straight through" between the type B input socket and the type A output socket, so normal operation can continue.

The Vbus line has a 1Ω 1% resistor connected in series with it but this is normally shorted out by a jumper shunt (JP1). When you want to measure the current being drawn from the host PC by the USB device, you simply remove the jumper shunt and connect a DMM between the two ends of the resistor. The resistor then acts as a current shunt, converting milliamps into millivolts.

So by switching your DMM to its lowest DC voltage range (say 0-2V), you'll be able to measure the device current in milliamps very easily.

If you want to measure the bus



SC 03011

USB BREAKOUT BOX

*WHEN JUMPER SHUNT IS REMOVED (1mV = 1mA)

Fig.1: with jumper JP1 in place, all four USB lines basically connect straight through. The current is measured by removing JP1 and monitoring the voltage across the 1Ω resistor (1mV = 1mA).

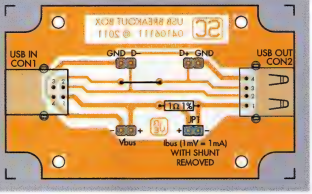


Fig.2: the PCB will only take about 10 minutes to assemble. Don't forget to solder the earth lugs on the sides of the USB sockets. The board can be fitted with rubber feet at the corners, or you can cut out the corners and fit the board into the base of a UB-5 zippy box.

voltage as well, this is easily done by connecting your DMM (set to the next higher DC voltage range) to the two pins of the other SIL pin strip (Vbus) on the top left of the circuit. In most cases, you should get a reading of +5V, unless there's a problem.

The two SIL pin strips near the bottom of the circuit are provided so you can easily monitor the D+ and D- signal line waveforms with an oscilloscope. As you can see from the scope grabs (Fig.3, Fig.4 & Fig.5), these signals take the form of bursts or "packets" of data at 1ms intervals. The data is encoded using a differential NZRI (non-return-to-zero inverted) format, with the D+ and D- lines pulsing in synchronism but with reversed polarity. To conform to the USB specification, both data line signals should have a peak-to-peak amplitude of between 3.0V and 3.7V.

Note that while the outer screens of CON1 and CON2 are connected together, to preserve the continuity of the USB cable screen, they are not connected to the USB cable ground (ie, pin 4) inside the breakout box. This is necessary to make sure that the box doesn't disturb the operation of the screen in USB 2.0 cables.

I should note here that the main information you'll be able to get from the D+ and D- waveforms is their peak-to-peak amplitude, whether they are switching in the correct differential fashion and whether they're both fairly constant in amplitude rather than varying sporadically or cyclically – either of which are indications of problems. It's not easy to get much more information than this because of the differential NZRI encoding.

Parts List

- 1 PCB, code 04106111, 76 x 45mm
- 1 PC-mount USB type B socket (CON1) (Jaycar PS-0920 or Altronics P1304)
- 1 PC-mount USB type A socket (CON2) (Jaycar PS-0916 or Altronics P1300)
- 1 1Ω 1% 0.25W resistor
- 1 SIL 8-way pin header strip
- 1 jumper shunt
- 4 self-adhesive rubber feet

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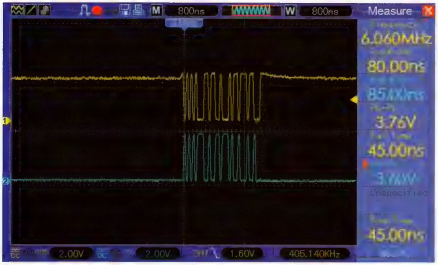


Fig.3: a single USB control packet showing the differential NZRI encoding (D+ in yellow and the D- in blue). The frequency reading is not relevant but note how the two waveforms have approximately equal P-P amplitudes.

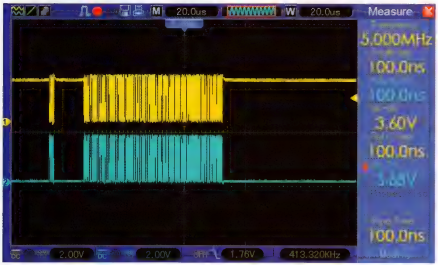


Fig.4: another capture of the D+ and D- signal waveforms, at a slower time-base rate. Here we see a control packet, followed by a much longer data packet. Again the frequency reading is not relevant.

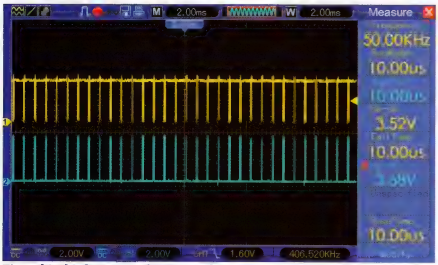


Fig.5: this third capture of USB signal waveforms is at a much slower rate again, and shows the way the D+/D- data packets are sent at intervals of 1ms. Again, the frequency reading is not relevant.

Fig.2 shows the assembly details. It's just a matter of installing the parts as shown, not forgetting the wire link. The four 2-way pin headers are snapped off an 8-way header.

The corners of the board can be fitted with rubber feet or it can be mounted in the base of a standard UB-5 zippy box.

In use, jumper shunt JP1 is removed if you want to measure the voltage across the 1Ω resistor, to determine the current.

Protocol analyser

Like most tools, the breakout box is handy for what it does but inevitably has its limitations. For examining USB bus operation in more detail once you've checked the basics, you really need a USB protocol analyser which can look at all of the control and data packets flying back and forth along the bus, identify those coming from the host and those returning from the device. This will let you see what's happening (or not happening, when it's supposed to).

There are a few software USB protocol analysers currently available, which can be very handy for this "deeper" level of troubleshooting. As the name suggests, these are basically software programs which run on the PC and "keep an eye" on the activity at any designated USB port, so that they can either display it in "real time" or save all of the information in a log file which you can open later and examine in detail.

One of these software USB protocol analysers I can recommend is *USBTrace*, developed and marketed by a firm called SysNucleus. A free 15-day evaluation copy of *USBTrace* can be downloaded from their website at **www.sysnucleus.com** and although it's a bit restricted in terms of the data it can save during a single session, it's still quite handy.

If you want the full version, this can be purchased online for US$195.00. Also available for free downloading are software decoders for the various USB device classes, so *USBTrace* can be more informative about their operation.

There's also a Microsoft "USB Device Viewer" software tool called *UVCview.exe* which can be quite handy when you're troubleshooting USB device operation. It's part of Microsoft's Windows Driver Kit (WDK), which can be downloaded for free from **www.microsoft.com/downloads/**

The latest version at the time of writing is V7.1.0, which comes as a 618MB ISO file. This must be burnt to a CD-R before *UVCview* can be installed.

SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.

Wireless doorbell relay driver

This circuit is a novel way of using a cheap wireless doorbell (available from eBay or from a discount store) to control a relay.

In operation, a battery-powered doorbell receiver is used to trigger a 4027 flipflop (IC1a) that's connected to toggle its outputs on each clock input.

The doorbell receiver has an output signal that changes state on receipt of a doorbell transmission. It's usually high when the doorbell pushbutton transmitter is pressed and low otherwise. This signal clocks flipflop IC1a to turn the relay on or off via transistors Q2 & Q3.

The circuit is powered from a 5V rail which is reduced to a nominal 4.5V via diode D1 to also power the doorbell receiver. The circuit controls a 24V relay which is powered from a separate 24V supply rail.

Thomas Drage,
Bassendean, W.A. ($50)

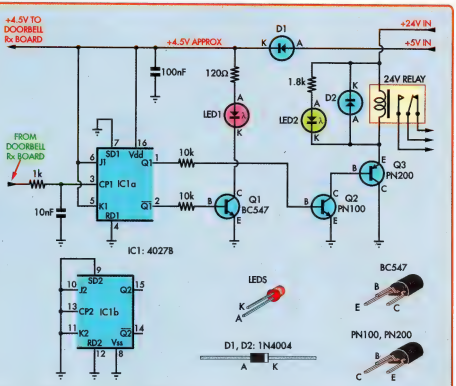


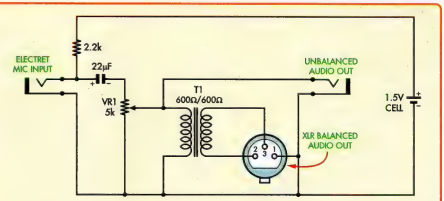
Fig.1: this circuit alternately toggles the relay each time the doorbell button is pressed. Note that you must use a battery-powered doorbell receiver (ie, NOT directly mains-powered) to provide the input signal.

Microphone adaptor for a violin

This adaptor was devised to enable me to play violin with a small dance band. It amplifies my instrument using one of the microphone inputs on their sound equipment.

As shown, an electret microphone is coupled to a 5kΩ potentiometer via a 22µF electrolytic capacitor. The potentiometer sets the signal level into a 600Ω isolating transformer which then drives a balanced microphone input via an XLR socket.

The electret insert was secured within some sponge foam under the fingerboard and connected to a 3mm jack socket fitted in the rear of the violin. A long audio cable connects the violin socket to the adapter which is housed in a small jiffy box.

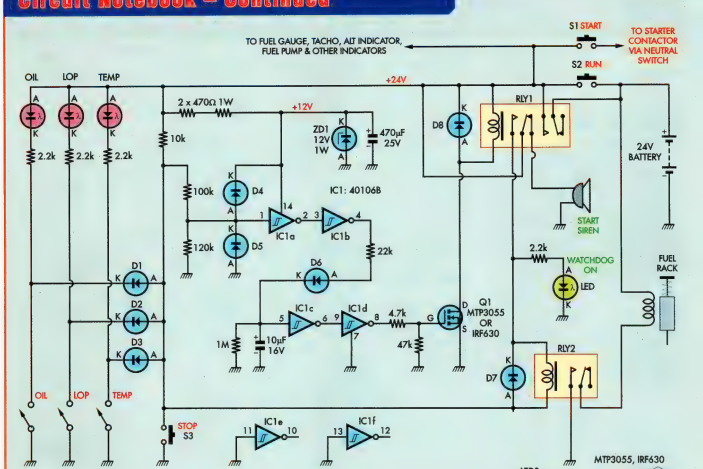


It runs from a single 1.5V AA cell in a battery holder attached inside the box with double-sided adhesive tape, as is the transformer.

Power is disconnected when the cable jack from the violin is removed from the 3mm socket.

Editor's note: for best results we suggest the use of a good quality 600Ω isolating transformer such as Altronics M-0709 or M-0707. This type of transformer was used in the passive DI box (SILICON CHIP, May 2006) with excellent results.

Colin Christensen,
Redcliffe, Qld. ($45)



Diesel engine watchdog circuit monitors oil pressure & water temperature

This watchdog was devised after I destroyed a Caterpillar diesel engine when a stick harpooned an oil filter. Ear muffs meant that I did not hear the alarm or the disintegrating metal. Mud on the dashboard obscured all indications and gauges.

The watchdog shuts down the fuel line to the injectors in the event of a fault condition being detected, turning off the engine and preventing damage. It is wired in place of the ignition switch.

It works as follows: to start the engine, first the "run" switch S2 must be held down for a short period. This connects the watchdog circuit to the 24V battery. A 12V rail is derived from the 24V supply by zener diode ZD1, bypassed with a 470µF capacitor and supplied via two 470Ω 1W current-limiting resistors. This rail powers IC1, a quad Schmitt-trigger input inverter.

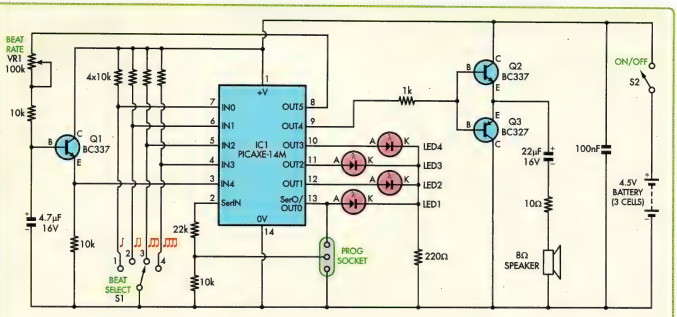
The "oil", "lop" & "temp" switches shown at the lower left of the diagram are the fault sensors and assuming there are no faults, they are all open-circuit. If so, the 10kΩ resistor pulls the input of IC1a high via a 100kΩ/120kΩ resistive divider. This divider prevents IC1a's input from exceeding 12V. Clamp diodes D4 & D5 further protect it from excessive voltage.

As a result, IC1a's output is normally low which means that inverter stage IC1b's output is high. This charges the 10µF capacitor at IC1c's input via a 22kΩ series resistor and diode D6.

Once that capacitor has charged sufficiently, the output of IC1c goes low and therefore the output of IC1d goes high, turning on Mosfet Q1 via a 4.7kΩ resistor. This energises the coil of relay RLY1, which has a diode (D8) across it to absorb any switch-off spikes.

When S2 is first pressed, power is applied to the start siren, so it sounds. Once RLY1 is energised, the siren is disconnected from the 24V rail. At the same time, the "watchdog on" LED lights to indicate that the watchdog circuit is operating. RLY1's second set of contacts closes across S2, shorting it out and so latching the 24V power on as long as the watchdog operates.

At this point, the start switch (S1) can be pressed. Assuming that the transmission is in neutral (and thus the "neutral" switch is closed), power is applied to the contactor and so the engine starts.



LEDS

BC327, BC337

PICAXE-based metronome with accented beat

This metronome is based on a PICAXE14M microprocessor and includes an accented beat function. This allows the musician to select a different sound on every second, third or fourth beat. General operation of the metronome is under control of the PICAXE software and you can find out more by reading the comments in the program listing.

In previous articles in SILICON CHIP, Stan Swan nominated the PICAXE as the new 555 timer and perhaps this circuit proves his point by functioning like the classic 555 astable multivibrator. The 4.7µF capacitor at the base of transistor Q1 is alternately charged and then discharged by output 5 of the PICAXE (pin 8) and associated components, working between upper and lower threshold levels established by input IN4 (pin 3). Within the program, input IN4 is operated in the A/D converter mode, allowing accurate setting of the two threshold levels.

This means that the 4.7µF capacitor provides the basic beat of the metronome, with potentiometer VR1 varying the capacitor charge and discharge currents to set the beat rate. Emitter follower Q1 is used as a buffer between the capacitor and the PICAXE input. If you require a slower beat rate, just increase the value of the capacitor.

Switch S1 selects continuous or accented beat operation while the four LEDs are included to give a visual display of the selected beat. Output 4 (pin 9) drives the complementary transistor buffer (Q2 & Q3) and the 8-ohm loudspeaker which is coupled via a 22µF capacitor.

The normal ticking sound and also the accented beat sound are actually short bursts of audio tone and not just a single pulse, as this gives a much louder and more effective sound. The speaker should be mounted in an enclosure or you will not obtain maximum loudness.

The software, Metronome_pgm.bas, can be downloaded from the SILICON CHIP website.

Ian Robertson,
Engadine, NSW. ($80)

If at any point one of the sensors registers a failure, its corresponding warning LED is switched on. At the same time, the input to IC1a is pulled low via the 100kΩ resistor and the diode connecting that sensor line to it (D1, D2, D3, etc). More sensors can be added, simply by connecting more diodes and LEDs in the same manner as shown.

When a sensor activates, this also completes the circuit for the coil of relay RLY2, switching it on and thus powering a solenoid that cuts fuel to the injector rail, shutting down the engine. Then after a second or two, the 10µF capacitor at the input of IC1c discharges enough for IC1c's output to go high, ultimately turning off Mosfet Q1 and thus RLY1, shutting the watchdog down entirely.

The watchdog can also be shut down by pressing the "stop" button (S3) which has the same effect as a sensor operating.

The type of solenoid to use depends on the engine being controlled. Diode D7 quenches any inductive spikes when RLY2 switches off.

Since the watchdog shuts down completely after the engine is cut, it can be used unattended (eg, for engine-driven pumps) and will not discharge the battery after a fault. Note that this circuit may not be suitable without modification for turbocharged engines as it may be necessary to idle the engine for a period before shutting it down.

Merv Thomas,
Townsville, Qld. ($80)

Multi-decade period-multiplier for precision frequency comparisons

This circuit was built to enable very precise calibration of a Rubidium Frequency Standard unit against a GPS-derived frequency standard. It uses the 1-pulse/second signal from a GPS-based frequency reference to generate a very accurate long-duration gate-control pulse for a frequency counter.

The GPS-Based Frequency Reference (SILICON CHIP, March & April 2007) or a commercial unit (eg, Trimble Thunderbolt) would be suitable. The signal to be calibrated or compared would typically be 10MHz from a stable oscillator. A 7-digit frequency counter with a 1-second gate period will have a resolution of 1Hz, being one part in 10^7 for a 10MHz signal.

If the gate time is increased to 10 seconds, the counter will repeatedly overflow but the resolution will become 0.1Hz, giving one part in 10^8 for a 10MHz signal. The Multiplier can extend the resolution to one part in 10^{13}, averaged over one million seconds (just under 12 days).

I used a Hewlett Packard 5301A 7-digit counter which has a TTL-level gate input. Many other frequency counters would also be suitable.

The circuit uses mostly 4000-series CMOS ICs. The 1-pulse/second GPS signal is fed into a 4584B non-inverting Schmitt trigger buffer (IC1a,b) and then to a chain of six 4017B decade counters (IC2-IC7). A 7-position switch (S3) selects the output from the Schmitt buffer or any of the decade counters.

This switched output triggers a D flipflop (4013B) which will change state every 1, 10, 100, . . . or one million seconds, as chosen.

The Q output of the 4013B (IC9b) drives a complementary transistor pair to give a low impedance output to drive the counter gate. The Hewlett Packard counter gate is open on LOW but if another counter required a HIGH to open, the Q-bar output would be used instead. Note that the gate is open for every alternate counter period.

The 9-to-0 transition of each counter advances the next-higher counter by 1 and when selected by the 7-position switch is used to toggle the flipflop. A reset switch sets all counters to zero and sets the 4013B to close the frequency counter's gate. Thereafter, the gate will not open until after one complete count period. This could be 11 days later!

Therefore, a 7555 variable-frequency oscillator with a wide frequency range (set by potentiometer and range switch) has been included. The oscillator is only active and connected to the counter input while its pushbutton is held on. It allows the counter chain to be pre-loaded to near the end of its period. Each of the 4017B counters has a LED connected to its "9" output pin; it lights only on a count of 9.

The circuit must run off a +5V power supply in order to ensure a correct TTL output signal. Current drain is around 30mA, depending on which LEDs are lit.

When using the Multiplier, only those counters up to the decade selected by the 7-position switch should be pre-loaded to "9" but do not let the two least significant counters reach "9" after the relevant more-significant digits are set to "9". Slow the oscillator down as you approach the end of pre-loading. It is too easy to overshoot and start the count by mistake!

If this happens, use RESET to stop the count, clear the frequency counter display and pre-load again. It is vital that the Multiplier be started only by a correct GPS 1-second pulse.

The Hewlett Packard 5301A counter does NOT clear its display before starting to count when its external gate control is used. Therefore, be sure to clear its display manually before making any measurement.

I also found that my HP counter has a slight additional delay (~0.6µs) when opening compared with closing its gate but only when using the external gate control. The result is always that it loses six cycles of a 10MHz signal for any counting period. This effect can be easily identified and overcome as follows: feed the GPS 10MHz output into the frequency counter and observe the displayed value for repeated periods of 1s, 10s and 100s (or more). In every case, the display should be "0000000" ±1 count.

In my system, I always obtained 9999993 or 9999994. The solution is to add "6" to the least significant digit displayed after any measurement, regardless of the selected measuring period.

I have used this circuit to set a Rubidium frequency standard to within three parts in 10^{12} against a Trimble GPS Standard, with very good repeatable measurements, using five decades.

Garth F. Jenkinson,
Emerald, Vic.

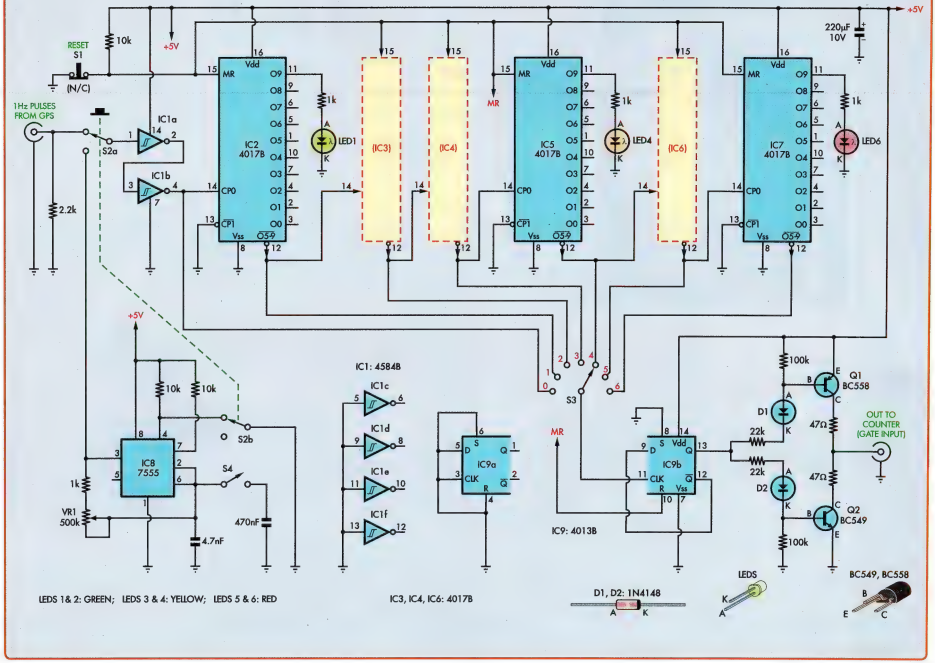
Garth Jenkinson is this month's winner of a Peak Atlas Test Instrument

Contribute And Choose Your Prize

We pay for each of the "Circuit Notebook" items published in SILICON CHIP but there are three more reasons to send in your circuit idea. Each month, at the discretion of the editor, the best contribution published will entitle the author to choose a prize: an LCR40 LCR meter, a DCA55 Semiconductor Component Analyser or an ESR60 Equivalent Series Resistance Analyser, with the compliments of Peak Electronic Design Ltd – see www.peakelec.co.uk

So now you have even more reasons to send that brilliant circuit in. Send it to SILICON CHIP and you could be a winner.

You can either email your idea to silicon@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.


+5V
RESET
S1
(N/C)
10k
1Hz PULSES FROM GPS
S2a
2.2k
IC1a
IC1b
IC2 4017B
IC5 4017B
IC7 4017B
Vdd
MR
CP0
CP1
Vss
O0
O1
O2
O3
O4
O5
O6
O7
O8
O9
1k
LED1
LED4
LED6
(IC3)
(IC4)
(IC6)
220µF 10V
S3
IC8 7555
S2b
S4
VR1 500k
4.7nF
470nF
IC1: 4584B
IC1c
IC1d
IC1e
IC1f
IC9a
IC9b
IC9: 4013B
100k
Q1 BC558
D1
D2
22k
47Ω
OUT TO COUNTER (GATE INPUT)
Q2 BC549
LEDS
BC549, BC558
D1, D2: 1N4148
LEDS 1& 2: GREEN; LEDS 3 & 4: YELLOW; LEDS 5 & 6: RED
IC3, IC4, IC6: 4017B

PRODUCT SHOWCASE

Quick Circuit PCB Prototyping System from SATCAM

The Quick Circuit Model 3000 PCB Prototyping system provides a cost effective alternative to other rapid prototyping machines.

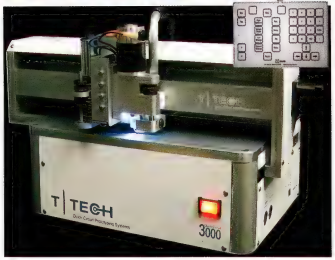
Its small footprint and economy pricing make this machine ideal for the educational, R&D laboratory and "less-frequent-user" markets.

As the first Quick Circuit machine of its size, the Quick Circuit 3000 PCB Prototyping system is a real space saver for cramped environments, and weighs in at just 13kg. The Quick Circuit Model 3000 PCB Prototyping system offers all the customary Quick Circuit precision and repeatability in a compact integrated package.

As with other Quick Circuit models, the Quick Circuit 3000 comes with a fully-featured licence to IsoPro and has the flexibility to perform precision engraving and machining of control and enclosure panels and labels, as well as its primary application of milling prototype circuit boards.

Although compact, the Quick Circuit 3000 PCB Prototyping system includes standard features such as USB interface and LED work area illumination, while options include pneumatic Z-axis drive, sound enclosure, "TraceCAM" work area camera, "QC-key" machine control keypad, DXF import, G-Code export and more.

Quick Circuit is designed and manufactured in the USA.



Contact:
SATCAM
823 Victoria Road, Ryde NSW 2112
Tel: (02) 9807 7081 **Fax:** (02) 9807 7083
Website: www.marantz.com.au

Visaton miniature speakers fit where most speakers don't!

German loudspeaker specialist Visaton now have a large range of miniature speakers suitable for medical, industrial, projects, signalling, communications & model construction and more. Starting at a tiny 16mm in size these speakers can be put into some of the smallest spaces with excellent performance.

They come in a range of shapes, sizes and impedances and are suitable for where space is at a premium. Models include various sizes such as 23mm, 28mm, 36mm, 50mm and more; PCB mount, terminals or wired options are available.

Contact:
Soundlabs Group
PO Box 276 Campbelltown NSW 2560
Tel: (02) 4627 8766 **Fax:** (02) 9807 7083
Website: www.soundlabsgroup.com.au

Inmarsat Satellite Phone from Av-Comm

They say mobile phones cover 96% of the Australian population. What they don't say is that 96% is in about 4% of the continent!

When you go "bush" or sailing or... wherever a mobile phone won't reach, a satphone will!

Calls are fairly expensive (~$3c/minute) but if you really do have to make that call, what price is too high?

Av-Comm have available this prepaid Inmarsat phone, complete with soft case and charger, for $900 inc GST, plus delivery. This includes 100 call credits (~100 minutes) with two year expiry (renewable, of course).

Contact:
Av-Comm
PO Box 225, Brookvale NSW 2100
Tel: (02) 9939 4377
Website: www.avcomm.com.au

Zigbee Wireless Sensors

The Zigbee Wireless (IEEE 802.15.4 protocol) modules from Ocean Controls can be used in applications such as industry and building automation where wide-area monitoring or control is required. The modules operate in the 2.4GHz license-free band and have a range of 120m (line of sight). This distance can easily be extended by the use of routers.

The modules can be quickly configured into a Tree-type structure with a PC connected to a central coordinator and routers allowing the I/O modules to be distributed around a factory or compound.

The I/O modules feature a temperature/humidity unit, analog input/output units and digital input/ output units. Ocean Control's ISEE-Modbus TCP software can monitor and control the modules from a PC.

Prices start at $149+GST for the Wireless I/O modules and ISEE-ModbusTCP software.

Contact:
Ocean Controls
PO Box 2191, Seaford BC, VIC 3198
Tel: (03) 9782 5882
Website: www.oceancontrols.com.au

Altronics' versatile stereo audio mixer suits professional or home use

If you're looking for an audio mixer to suit just about any application, this one from Altronics could be just the shot!

With up to nine input sources (four main channels are stereo) and five output channels, this stereo mixer also offers variable echo, repeat and delay, a three-band graphic equaliser, fader controls between channels two and three and a program cue selector allowing a DJ to cue upcoming tracks via headphones.

As you'd expect, each channel has its own level adjustment and there's a master level control as well. Each of the four stereo inputs can be switched via the front panel from mic level (1.5mV/10kΩ) to line level (150mV/22kΩ).

It suits a variety of uses from pro-style DJ work, public address systems, dubbing audio onto home videos, karaoke . . . in fact, just about any audio mixing application you can think of. Retail price is $199 (Cat A2551).

It's available from any Altronics store, reseller or the phone/mail order/online store.

Contact:
Altronic Distributors Pty Ltd
PO Box 8350, Perth Busn Centre, WA 6849
Tel: 1300 780 999 **Fax:** 1300 790 999
Website: www.altronics.com.au

RS Components catalog: get it three ways!

RS Components have released their new 2011 catalog – and it's available in three formats: (1) traditional printed version; (2) digital (CD) version and (3) online version.

There are over 75,000 products in the new catalog, with all products in stock and available for immediate delivery.

All 450,000 products in the RS range may be accessed online, with RS online introdcing new products every month.

Contact:
RS Components
25 Pavesi St, Smithfield NSW 2164
Tel: (02) 9681 8558 **Fax:** (02) 9681 8614
Website: www.rsaustralia.com

SparkFun Electronics creates Department of Education

Lots of Aussie electronics enthusiasts order difficult-to-obtain or oddball parts online from SparkFun Electronics, a US company specialising in helping electronic enthusiasts get the parts and resources they need.

Now SparkFun is announcing a new department – the Department of Education.

SparkFun Electronics always has focused on Sharing Ingenuity – providing extensive online resources as well as offering a variety of in-house workshops and events. The recent development of a new Department of Education within SparkFun emphasizes the company's passion and commitment to providing individuals with the tools they need to explore the world of embedded electronics.

For more information about SparkFun's new Department of Education, contact education@sparkfun.com.

Contact:
SparkFun Electronics
6175 Longbow Dve, Suite 200, Boulder, CO 80301
Tel: 0011 1 1 303 284 0979
Website: www.sparkfun.com

Pocket-size decontamination wipes off toxic dangers to workers

Enware is introducing to Australasia a toxic chemical Decontamination Mitt, so effective that versions of it are used by armed forces to neutralise deadly Chemical Warfare Agents.

The Decon Mitt consists of a pouch containing wipe-down mitt impregnated with decontaminating powder called FAST-ACT. A soft pad material is backed on the mitt by a film, to protect the user from any contamination by substances to which it is applied.

FAST-ACT as used in Decon Mitts is a non-toxic, non-corrosive and environmentally friendly sorbent that provides better chemical protection and decontamination capabilities than currently available industrial technologies.

Contact:
Enware Australia Pty Ltd
9 Endeavour Rd, Caringbah NSW 2229
Tel: (02) 9525 9511 **Fax:** (02) 9525 95367
Website: www.enware.com.au

WES' new range of CB radio gear

WES Components have released a PDF showing an extensive range of UHF and 27MHz CB radio antennas, mounts, bases, brackets and other goodies.

To have a look at their range, call in to the WES Showroom (see right) or log onto http://wesnews.wescomponents.com/wesnews/WN204UHF.pdf

Contact:
WES Components
138 Liverpool Rd, Ashfield NSW 2131
Tel: (02) 9798 9233 **Fax:** (02) 9798 0017
Website: www.wagner.net.au

Vintage Radio

By Kevin Poulter

An insight into the manufacture of quality valve radios in the USA nearly 100 years ago

Radio Manufacturing in 1925: the Wells Gardner story

This month we take a look at high quality radio manufacturing during the 1920s in the USA. This was on a much larger scale than in Australia but the methods were largely the same, with similar machinery and tools.

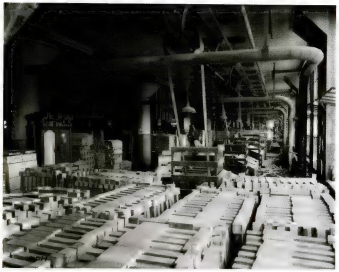
In the 1920s, radio manufacturing proliferated. *Yet from the thousands of companies that then existed, few images of production were ever taken or remain. It was considered a breach of security for an employee to photograph inside a factory so some factories eventually closed without a single photograph taken.*

Fortunately the US company Wells Gardner produced some images, most likely for salesmen to show stores that they were a big operation and not just a suburban garage or tiny factory. This provides us with wonderful insight into the manufacturing techniques of the late 1920s.

In 1925 production started at Wells Gardner with a discussion between the Manager, Sales Manager and Design, regarding the best radios to meet market trends. In the mid to late 20s, the only choices were a console radio, a "coffin" bread-box style, or a mantel in a wooden cabinet – and how many valves to have in the design. As was common practice, a number of brands were used, with many consoles and huge table sets sold under the M. Wards' "Airline" name.

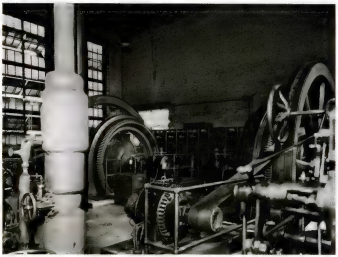
This strongly influenced the selling price and most manu-

facturers had economy and top-end models. It appears that Wells Gardner mainly supplied the top end of the market, as many of their radios were nine-valve.



A major part of the production at that time was huge stacks of fine timber and the best craftsmen to fabricate it into beautiful cabinets.

When the design was completed and approved, parts were ordered in and kept in the secure store. Staff had no access, as many liked to build their own hobby radios or knew people that did and may otherwise have 'lifted' some parts.



The 'engine room' generated all of the electric power required by the factory and offices, due to the generally unreliable reticulated power at the time.

Not having enough of some parts to complete a production run was even worse than the pilfering, as production, distribution and sales were all then delayed.

Many components were made in-house, though most likely not valves nor capacitors, as they were more specialised. Transformers and coils were definitely made in the plant, as they often were in Australian factories of the era. Here women wind and assemble coils.

Transformers made in the factory were tested in a jig, with seven meters plus an auxiliary meter. The jig's contacts match the pins on the transformer, and the lever in the centre applied a little pressure to ensure all contacts were sound. So the test was essentially automated - place the transformer upside down on the jig, push on the lever and switch on.

When all the components were made or purchased in, a production run commenced. Each section had a supervisor (you can just see his hat in this photograph) to ensure the people worked hard and to a good standard. Toilet breaks were generally not permitted. He was also expected to ensure the continuous supply of parts to the line.

In the foreground, wires are being cut to length, stripped on their ends and pre-tinned with solder. Some would have heat-resistant sleeving added. Prepared wires were included in looms or used singularly for direct links between components.

The following photographs show the construction of a nine-valve receiver. All the radios were assembled using the factory jig, with handles to enable easy roll-over of the chassis.

Looms were made in factory, to connect most of the components together electrically. A loom jig was a piece of wood with the loom plan drawn on paper and attached. Conventional building nails in the wood guided every bend and other nails indicated the end of each wire's course.

When a wire was run though to its destination, it was terminated by winding once around the end nail and then cut off. On completion, the entire loom was hand-stitched together and/or bound with cloth strip.

Eighty years later, this exact method is still used to make custom looms for vehicle restoration.

The male in the centre of the above picture is the supervisor, with his desk in the foreground.

THE GALLERY: SOME OF WELLS GARDNER'S RADIO MASTERPIECES

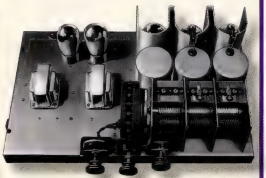
92-1929

WG-82

WG-161

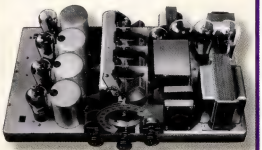
1933 Airline Superhet and a closeup of the dial

Wells-1933 A 1933 console radio



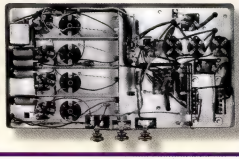
Five valve chassis WG-30-126-2

These chassis were photographed in a studio, printed to a large size, air-brushed and retouched, then the retouched image photographed again, resulting in the final negative and print. Today we use Photoshop, saving an immense amount of time and cost.



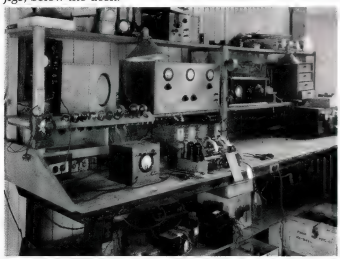
Eight-valve WG-30-106-3 showing top side and underchassis

The connection loom between the two chassis appears to be covered by winding a fabric strip over, an early version of the tape used in later looms.



Production was not easy for the staff. Conditions were high-pressure and the area poorly lit. Note the 4-gang variable condensers and the age of the women – from teens to seniors. The caged area in the rear is most likely a lockable store.

The final assembly was mainly done by men, with the woman on the far right probably a long-term employee with advanced experience. A supervisor stands on the far right and in the foreground there's a row of disassembled jigs, below the desk.



The final test bench has custom-built test equipment, Burgess "B" batteries, plus wet cells near the floor and spare valves if needed. The photograph is so clear, some boxes of RCA UX-280 valves can be seen at the top and a row of valves in the centre. There's a screwdriver, radio pliers, soldering iron and an open end spanner on hand too.

About these photos: restoration from glass negatives by Kevin Poulter*

The images in this feature were 'rescued' from an American owner and were reproduced from the original glass-plate negatives.

The images were top quality, as the photographers almost certainly shot them in a view (bellows) camera.

It's likely they had at least one incandescent spot-lamp, however shutter speeds still needed to be down to about one second or even longer. The result was at least one of these images showed double-imaging.

The sheer size of the glass negatives – four inches x five inches – overcame the low quality of the lenses. These intrepid photographers had to load, carry and process glass plates! Some even coated their own plates (negatives).

Recently I used Photoshop to restore them to better-than-original. This included lightening the areas where the main photographic light was much dimmer in the distance, due to the inverse square law (the phenomena where doubling the distance reduces illumination to approximately one quarter). Other than the restoration mentioned, the images are identical to the day they were photographed.

As recently as the 1950s to 1970s, radio and television factory employees in Australia still worked in conditions similar to those shown here, seated in long rows, with the women doing the most repetitive work and men doing more advanced functions, like design, cabinet crafting and final testing.

*** Kevin Poulter is a professional photographer based in Melbourne. You can see more of Kevin's work at www.imageaustralia.info**

On completion, the radios were packed in wooden boxes, then when ready for shipping, were loaded into a rail car at the company's own rail siding. **SC**

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See the review in April 2011 SILICON CHIP.
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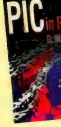

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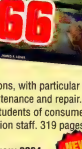

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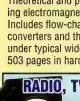

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How accurate is GPS speed measurement?

I have noticed that in the work car, to drive at 110km/h by the GPS unit (a well-known brand) I need to drive at close to 125km/h by the vehicle's speedometer. While I realise that the car speedometer is probably reading high, I am aware that the GPS unit approximates the Earth's surface and therefore potentially also is in error.

Using the other traffic as a guide, I expect that the GPS unit is reading fairly accurately but given the expense should I get it wrong, I was wondering how much of an error will the GPS unit produce – is it close enough that the "grace factor" applied by the speed camera units cover the potential error of the unit? (T. M., Paradise, SA).

● This topic of large vehicle speedometer error has been discussed in the past and is a consequence of the Australian Design Rules which specify that the speedo must be optimistic (ie, give a high reading) while the odometer is supposed to be highly accurate.

Your experience is typical. While there is bound to be a small GPS speed measurement error you can expect it to be less than 1%. By comparison, vehicle speedos are typically 8-9% high in their readings at speeds of 100km/h or more. Be warned though, vehicle speedometers are usually fairly accurate between 40km/h and 70km/h. So don't go above the speedo indication in areas with these speed limits otherwise you risk being booked.

Is there any point in float charging?

I have a number of devices that use 12V SLA batteries in charge/discharge service, some of them only occasionally. When fully charged, the charge drops back to a trickle, about 10mA. I notice that if I disconnect the charger completely for days or even weeks, on reconnection it charges for about 20 seconds before dropping back to float.

So it would appear that I am only wasting power (about 15W in total) by leaving these things on continuously. So is there any benefit in leaving them on permanent float? Despite spending a lot of time trawling the net, I have been unable to find a satisfactory answer to this. (G. H., Mt Martha, Vic).

● SLA battery manufacturers recommend a float voltage between 13.5V and 13.8V to maintain charge and to provide maximum battery life. If you have a battery-operated device which is normally off then there is probably not a lot of point in leaving it on float charge. However, you will need to charge it from time to time to prevent self-discharge from taking the battery below 11.5V which will cause it to fail.

In other circumstances, with larger batteries, float charging is recommended (see the answer below).

Seldom-used batteries need float charging

A friend in Melbourne recently asked my opinion as to whether SLA batteries should be constantly float charged. I said "yes".

The slightly higher voltage on the float charge prevents the formation of a permanent lead-sulphate layer on the lead electrodes. Once a sulphate layer has formed, it creates a barrier between the positive and negative plates, resulting in a higher internal resistance and decreased capacity of the cell. If this lead-sulphate becomes permanent due to a lack of recharging, it becomes an inert substance in the charge and discharge process.

His concern was that, to float charge two SLA batteries (one in a golf caddy and the other in an electric bicycle), the chargers continually used 12W. In winter, the batteries stood unused for many months, which seemed to be a lot of wasted power.

I thought that without float charging, the battery capacity would shrink a lot faster. I suggested that a more ef-

Preamplifier For A Flexible Piezo Film Sensor

I'd like to use the Pre-Champ (SILICON CHIP, July 1994) to amplify the signal from a flexible piezo film sensor – see **http://www.meas-spec.com/product/t_product.aspx?id=2478#**

However, what would I need to do to match the Pre-Champ to such a high-impedance load – possibly two, either in series or in parallel? I'm not too sure at this stage if it would be worse for bass response.

Is there a frequency response chart available for the Pre-Champ preamplifier? (P. S., Lane Cove, NSW).

● The data sheet indicates that the recommended load impedance is 10MΩ, which you would need to get maximum bass response from the sensor. With this in mind, the Pre-Champ is never going to the job. Besides which, its -3dB bass roll-off is at 72Hz – not good enough, in all probability.

Instead, we suggest that use the single-transistor preamplifier circuit featured in Circuit Notebook in June 2002. This could be lashed up on the PreChamp PCB and does provide a load impedance of 10MΩ.

Note that the potential output of the sensor could range up to several hundred volts and this could be a real problem with the suggested preamplifier (or any other preamplifier, for that matter). If you are proposing to use it on a musical instrument, the signals might not be that strong.

You might need to check the likely signal amplitude with a scope, using a 10MΩ probe.

Using LEDs With The Digital Lighting Controller

Would it be possible to include a low voltage output option for the Digital Lighting Controller (SILICON CHIP, October - December 2010) slave unit so that strings of LED lights could be connected directly? This would then take the place of the multifunction controllers that lights in the shops use, especially when they fail after a year. (L. B., Auckland, NZ).

● If your LEDs run off AC (some do) then the Digital Lighting Controller can drive them directly with some minor modifications.

Essentially, this just involves changing the mains connectors (both input and output) to something suitable for hooking up low-voltage AC. The slave module is slightly less efficient switching low voltage AC but it should work.

For DC-powered LED strings, it certainly is possible to build a Mosfet-based slave module (alternatively, Darlington transistors could be used). Ideally, this would contain an adjustable current sink for each channel although many LED strings run directly off 12V, which would simplify the design. The same logic IC arrangement could be used as in the AC slave, with the Darlington array and following components changed over.

In either case, the same master module can be used with a line in the configuration file to indicate which slave(s) are controlling DC loads. This is not strictly necessary but improves brightness control because with a DC load, brightness is proportional to duty cycle but with an AC load, it actually varies with the area under a sine curve.

By default the master module compensates for this; the added line in the configuration file disables that compensation for better brightness linearity.

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ficient (switchmode?) battery charger might help.

However, after some further thought I came up with another idea. He could use his chargers, which could be switched on and off using a time switch, with a duty cycle of perhaps on for one hour in 24 hours. This might be sufficient to reverse the sulphate layer before it became permanent (the battery manufacturers would have data on this). His electricity usage would certainly be lower. Is there a better way? (A. F., Chinderah, NSW).

● You are correct in recommending float charging in these applications. Leaving batteries to self-discharge over a period of many months, particularly in winter, is a big mistake as these batteries can be very expensive to replace.

It is even more important when applied to batteries in boats. These can be left for long periods and if they are not kept on float charge, they will be dead when you next need to use them. And we can vouch for the fact that boat batteries are very expensive, as is the cost of installation. Heavy batteries in awkward confined boat engine rooms can add up to lots of dosh.

In this particular case though, the original charger may start up in fast charge mode each time the timer powered it up. This may cause the battery to be initially boosted to the cut-off voltage before switching to absorption (if this is incorporated) and then to float. This could be worse for the battery as it would effectively be cycled between the two voltages. This would need to be checked.

A switchmode float charger might be best to use once the batteries have been charged by the main charger. The switchmode float charger could be cycled on and off with a timer.

Explanation of open-collector outputs

I have a comparator powered from a 15V rail. One of its inputs is fed with a 10V reference and other with the voltage it is comparing. I would like its output to go into my microcontroller.

Now the comparator (LM311) has an open collector output which means it'll need a pull-up resistor. But what I am unsure of is what do I pull it up to? Can it be 5V? Then it will be at the right level to interface to the micro or will it have to go through a zener diode to get down to the 5V level? Or does it have to be pulled up to its own supply?

My second question is this: I wish to get a 5V supply for a microcontroller and a couple of LEDs from either a AA or AAA battery using some sort of step-up regulator. Could you suggest any that come in an 8-pin package and are reasonably simple to work with? (B. W., via email).

● The LM311 comparator output is "open collector". This means that the collector of the output transistor is not connected internally. It requires an external resistor to a positive supply rail so that the output will be low when the transistor is switched on and it will be pulled high via the resistor when the transistor is off.

The open-collector feature means that the output can be pulled higher or lower to different supply rail from that feeding the LM311 comparator itself. For example, the comparator might be run from a 15V DC rail and the open-collector might be pulled via the resistor to a 5V supply. This could be useful in driving TTL circuitry or CMOS circuitry running from +5V. In your case, the pull-up resistor could be 10kΩ, for example.

A step-up supply running from one or two AA or AAA cells can be made using a TL499A. This was used in the

Latch-Up Problem In Ultra-LD Stereo Amplifier Preamp

A year or two ago I built the Ultra-LD 2 x 100W Stereo Amplifier. Its sound quality is superb but it has had one irritating problem ever since its completion that I can't solve.

Normally at switch-on, the bargraph LEDs flash momentarily and all is well. However, quite often they don't and when that happens, the bargraphs don't work when a signal is applied and the output is distorted as well. The only cure is to switch the amplifier off and on again. However, it may take two or three attempts before the amplifier "boots up" properly.

Investigation shows that, when it is not working properly, there is no positive voltage from the 7815 voltage regulator, even though the input voltage is there. The negative supply from the 7915 is OK.

I have replaced the 7815 voltage regulator and all components fed by it including the two TL072 bargraph buffers, the two 5534 preamp ICs, and the electrolytic capacitor between the output of the regulator and earth. I didn't replace the other electros that straddle the positive and negative regulator outputs because they seem to be OK. The problem, however, persists and I'm getting to the "wit's end" department.

I wondered if, at switch-on, the regulator might be seeing the discharged electros as a short-circuit and cutting out but why does this only happen sometimes and why is the negative side not affected? Please can you shed any light on this perplexing problem? (J. P., via email).

● Interestingly, we would not have had a definitive answer for this problem up until a few months ago and we would have simply advised you to check for defective components or bad soldering. However, in developing the Universal Voltage Regulator board that was presented in the March 2011 issue, we discovered that there is a serious problem when you have a pair of 7815/7915 or other 7800/7900 series regulators fed by positive and negative half-wave rectifiers. That is the exact situation in the preamp board of the Ultra-LD 100W Stereo Amplifier.

What happens is that, depending on whether the positive or negative rail comes up first, the regulator which turns on first will pull the complementary regulator's output up (or down) to the point where it latches up and prevents normal operation from occurring. In your case, the 7915 is turning on first and in charging its associated 100µF capacitor and the two 10µF capacitors across the two output rails, it actually pulls the output of the 7815 below 0V.

The poor old 7815 interprets this as an overload condition and latches up. So you have to turn the unit on and off maybe several times to get the correct power-up condition.

As far as we can determine, this fault condition only occurs with certain brands of regulator which is why we didn't see it when we were developing the Ultra-LD 2 x 100W Stereo Amplifier back in 2001.

The solution is to connect reverse-biased diodes across each regulator's output. You can see how we did this in the Universal Regulator circuit, in Fig.4 on page 40 of the March 2011 issue. The diodes in question are D5 and D6.

Water Tank Level Meter in the November 2007 issue and the 3-9V DC-DC Converter in March 2004.

Alternatively, the MC34063A could be used and this was the basis of the August 1992 step-up converter design.

LM2917 frequency-to-voltage converter

I have built the frequency-to voltage converter featured in the Circuit Notebook pages of the June 2010 issue. This was designed to allow air-flow sensors which have a variable frequency output to be used with your Voltage Interceptor published in "Performance Electronics for Cars" (a SILICON CHIP publication).

I am having trouble getting an output voltage close to 4V at the maximum frequency range of 100Hz to 150Hz. When the 10kΩ resistor is connected to the output and pins 5 & 10 bridged, the result is about 250mV. Readings without the 10kΩ resistor are a static 2.3V and only vary by about 2mV with adjustment of trimpot VR1.

I also note that there is no variance in voltage on pin 2 with adjustments to the input frequency. Pin 2 shows 900mV static at all input frequencies and pin 3 only has 2mV (also static). All input voltages to pins 8, 9 & 11 match those in the article. Any help would be very much appreciated. (F. E., via email).

● The LM2917 is available in many variants. The circuit shown in the June 2010 issue is for the LM2917N. Other LM2917s have different pin outs and you will need to check this before connecting up a circuit.

As published, the circuit is set for a nominal 40-400Hz range. For your narrow frequency range, the output will vary from 4V at 150Hz to 2.7V at 100Hz. The 10kΩ resistor is required between pins 5 & 10 to ground as the output is an emitter follower and the resistor provides the load.

The circuit will not work if the input signal does not swing over and below a 0.55V range. For more sensitivity use a lower value resistor instead of the 1kΩ value at pin 11.

Pin 2 switches charge to the capacitor at pin 3 and measuring the voltage at pin 2 does not indicate much about what is happening.

Using the Tempmaster to control an incubator

I would like to use my Tempmaster Mk2 to control a 300W heater in my poultry egg incubator. The required temperature is 37°C. Is it possible to adjust the resistor values in the "temperature set" circuit to extend the range of the Tempmaster to cover this temperature? (S. A., Echunga, SA).

● Yes, it is quite easy to adjust the resistor values in the temperature set part of the Tempmaster Mk2 circuit, to allow it to maintain a temperature of 37°C. In fact, there is only one resistor value that needs to be changed: the resistor from TP1 to the +5V line (pin 3 of REG1).

If you change this resistor's value from 2.7kΩ to 2.2kΩ, this will give VR1 an adjustment range from 3.00V to 3.166V, corresponding to temperatures

from 27°C to 43.6°C. The temperature will be set to your desired value of 37°C when VR1 is then adjusted to give a DC voltage of 3.10V at TP1.

Charge controller for power-tool batteries

Have you any articles on building a charger controller for power tool nicads? I have tried unsuccessfully with the temperature measurement method but am interested in a final voltage sensor/switch off.

- We did publish a Power Tool Charging Controller in the December 2006 issue and there was a companion article was in the same issue entitled "Bringing A Dead Cordless Drill Back To Life". This controller uses the rate of change in temperature at full charge (dT/dt). It also has over-temperature cut-out and a back-up timer is included.

NiMH and nicad cells cannot be checked for full charge by measuring their terminal voltage. This voltage is dependent on many factors, including temperature, charge rate, cell chemistry and the size of the cell. Instead, end of charge can be detected by the change (fall) in voltage at full charge or via the rapid rise in temperature. In practice, the change in voltage can be small and is difficult to detect reliably.

Car battery tester wanted

Would you consider a project for a car battery tester with a load that can be varied according to the battery capacity? (D. M., via email).

- Have you seen our Battery Condition Checker from the August 2009 issue? This should do the job for you. It uses Mosfets to briefly drag current pulses from the battery and it measures the battery output impedance.

The current pulse amplitude can be set to suit the size of the battery.

Minivox voice-operated relay is latched on

I purchased a Minivox Voice-Activated Relay kit (SILICON CHIP, September 1994) from Jaycar in Melbourne. When connecting it to a 12VDC power source the LED and relay activate without the action of the electret microphone. The relay and LED remain on. I have checked the connections and polarity according to the diagram and markings of the circuit board and all is correct.

When reading some past letters on this kit there appears to be some confusion about the correct diodes and their positioning/polarity orientation, etc. Is there a problem like this with the kit I have purchased? If not, what could the problem be? (I. G., via email).

- There was some confusion over the diodes in the Minivox project article. In particular, diode D1 should be orientated so that its anode is connected to the negative supply. Diode D3 on the PCB should be diode D4 and D4 should be D3. The orientation of D4 should be with the anode to the collector of Q1. The cathode (K) end of the diode has a stripe.

However, these problems would have been fixed in the Jaycar kit instructions. If in doubt, contact **kits@jaycar.com.au**

Check the pin 7 output of IC1b. This normally should be at about 0V. If it is above 3V or so, then there must be voltage at pin 5 that is above the voltage at pin 6. Pin 6 should be about 2V. If Pin 7 is at about 0V, transistor Q1 could have a short between emitter and collector or there is a short on the PCB.

Any voltage at pin 5 would mean that there is noise picked up by the microphone and signal is present at pin 1 of IC1. Or the 100nF capacitor at pin 1 is a short circuit or there is a short on the PCB.

Varying the gain of the PreChamp preamplifier

I built the 2-transistor PreChamp Preamplifier (SILICON CHIP, July 1994) to run electrets for a CB radio and it's a ripper.

I want to know if it's possible to put a variable pot somewhere to reduce the gain as sometimes it's very sensitive? I have tried a few points on the board but have not been successful. If it is possible, what value pot should I use and where does it go? (J. P., via email).

- The 100Ω resistor at the emitter of Q1 can be increased to reduce the gain. And ideally, the 22µF capacitor should also be reduced in proportion to the increase in resistance.

For example, if the 100Ω resistor is changed to 470Ω, the 22µF capaci-

Substitute Wanted For A Cassette Recorder

I tape our church service each Sunday so that "shut-ins" can hear the service during the week. The 120-minute tapes I use are becoming hard to get. I use just one side per service to save changing it over and perhaps missing something.

Unfortunately, a 60-minute cassette is often not enough. Could I use a DVD recorder instead and burn a DVD each week? If so, I assume I would have much more than 60 minutes of recording time available?

Some time ago, I tried using a VCR but must have done something wrong as I got nothing. If I did use a DVD, I would also have to buy a portable DVD player as many old folk may not have a means to play it. (B. P., via email).

- Unfortunately there is no simple replacement for the cassette recorder. Generally the best solution is to record so that a CD can be made instead. This involves recording to a memory and then transferring to the CD.

CD recorders are available but are not as simple to operate as a cassette recorder. You can record to memory using a computer or specialised digital recorder. One such device is the Gemini iKEY recorder that records in high-quality to a USB flash memory drive. Other recorders include the many MP3 players that have a record function.

A CD is the best medium to provide because most people will have a CD player, including the older people who find it difficult to get out of the home. Many would still have a cassette player but it may not be working due to the drive belts that perish.

A DVD recorder might work but we are not sure if a DVD recorder will record just audio when there is no video signal present although that could easily be provided using a video test generator.

We may look at the possibility of producing a high-quality recorder based on an SD card.

Next month in Silicon Chip: July 2011

Ultra-LD Mk.3 Amplifier Module:

This is a major update of the Ultra-LD audio amplifier module presented in the August & September 2008 issues and incredibly, has even lower distortion. The new design provides a V_{BE} multiplier transistor to easily set the quiescent current and address the shortcomings of the internal tracking diodes in the ThermalTrak power transistors. As well, it now incorporates 2-pole high-frequency compensation and some other small modifications to greatly improve THD.

Lightning Radio Warning Indicator

Designed around an TA7642 AM radio chip, this simple circuit will give an audio warning of lightning strikes from approaching thunderstorms – could be a life saver for trekkers, boaties and campers.

UHF Rudder Indicator

A boon for anyone with a twin motor cruiser, this UHF linked indicator will constantly tell you how the rudders are set. This is essential when doing low-speed manoeuvres such as docking and picking up a mooring when all steering is done with motor control.

Note: these features are in the process of preparation for publication and barring unforeseen circumstances, will be in the issue.

ON-SALE: Wednesday, 29th June 2011

tor would be reduced to 4.7µF. The capacitor change maintains the low-frequency rolloff at about 72Hz.

PICProbe modes are settable

I built up one of the PICProbes as described in the October 2007 issue of your magazine from a kit supplied from Jaycar. It seems to work but it's doing something a little odd – the red LED is constantly on until it is connected to a logic zero output. Probing a "state zero" will result in the green LED lighting and a pulse from the orange LED. Pushing the button results in the orange LED latching.

Is this correct operation as per the original design or is something wrong? (P. M., Wollongong, NSW).

● For the red LED to be on unless the probe is connected to 0V indicates that the probe is in the mode where a pull-up is enabled. This pull-up resistor can be disabled by holding the pushbutton in during power up. The probe should then have a floating input and the LED state is not defined until the input connects to a logic high (red LED on) or logic low with the green LED on.

If the orange LED stays on (with a press of the pushbutton), then the probe is probably set for the latching mode. This can be disabled by holding the button in for two seconds.

Large digital display could provoke road rage

Here is a project idea: a large alphanumeric static display you put in the back window of your car. In my case it would display three words sequentially when a button was pushed: "BACK OFF FOOL".

Maybe it could have several messages selectable on a console. I would certainly make one. (J. D., via email).

● You can already buy large moving marquee displays to perform that function. Mind you, with all the road rage these days, it might not be a good idea to provoke some people. SC

Notes & Errata

Digital Lighting Controller, October 2010: in the Master Unit circuit (pages 40-41), the connections for pins 4 & 5 of IC1 are reversed. The PCB pattern is correct.

The Microchip PIC32 (March 2011): on page 21, line 2 of the program listing is incorrect, it should read:

```
#pragma config FNOSC=FRCPLL,
FPLLIDIV=DIV_2, FPLLMUL=MUL_20,
FPLLODIV=DIV_4
```


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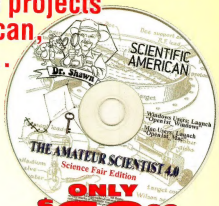

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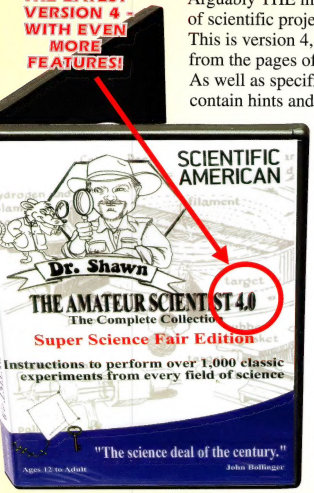

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- Cushion grip handles
- Flat, round, 1/2 round, square & triangular

$29 (F100)

PUNCH SETS

3/16" Letter $39 (P350)
3/16" Number $18 (P351)
5/16" Letter $49 (P354)
5/16" Number $22 (P368)

SOLID CARBIDE BURR SET
5 PIECE
- Double cut
- 3/8" & 1/2" sizes
- Industrial quality
- 1/4" shanks

SUPPLIED IN CASE

$79 (E800)

SCREW EXTRACTOR SET
10 PIECE
- Includes 1/8", 5/32", 3/16", 7/32", 1/4", 9/32", 5/16", 11/32", 3/8",13/32"

$24 (T970)

RATCHET TAP WRENCHES
- Forward/reverse operation & lock
- Designed for use with taps reamers screw extractors & other tools with a square shank

No.1 M3-M10 $14 (T890)
No.2 M5-M12 $18 (T891)

KEYED DRILL CHUCKS

Capacity	Taper	
0.5-10mm	JT2	$36 (C298)
0.5-13mm	JT6	$49 (C299)
0.5-16mm	JT3	$69 (C290)

INDUSTRIAL DRILL SET
Metric Set
- 25 piece
- Metric set
- Precision ground flutes, HSS M2 bright finish, 118° split point centre for
- 1-13mm range

1-13mm RANGE

$88 (D1271)

INDUSTRIAL DRILL SET
Imperial Set
- 29 piece
- Imperial set
- Precision ground flutes, HSS M2 bright finish, 118° split point centre for
- 1/16-1/2" range

$88 (D1281)

DRILL SHARPENERS
- EDBD-13 economy
- 80 Watts, 240V, 4200rpm
- 3-13mm capacity
- Split point capable
- 118° angle

$109 (D070)

TAP & DIE SET 32 PIECE
- Range: M3 - M12

Carbon Steel	HSS
$49 (T012)	$109 (T013)

DRILL CHUCK ARBORS

Size	Suits Chuck Size	
2MT x JT2	10mm	$12 (D4412)
2MT x JT6	13mm	$14 (D442)
2MT x JT3	16mm	$14 (D442A)
3MT x JT6	13mm	$18 (D443)
3MT x JT3	16mm	$18 (D443A)

COMBINATION DRILL & TAP SET
- HSS M2 bright finish
- Hex shank
- M3, M4, M5, M6, M8, M10mm
- Includes Hex snap-on for Hand Drill

$45 (T0191)

CENTRE DRILL SET
- Industrial quality
- HSS M2 bright finish
- No. 1, 2, 3, 4, 5

INDUSTRIAL QUALITY

$35 (D508)

INDUSTRIAL STEP DRILLS
- Suitable for sheetmetal
- Industrial quality
- HSS M2 bright finish
- Sizes: 4-12 x 1mm 6-20 x 2mm 6-30 x 2mm

$70 (D1071)

PORTABLE VIDEO SCOPE
- 2.4" color screen
- 1 Meter flexible shaft
- 9 volt battery
- Protective plastic carry case
- Includes pick up tools: magnetic, hook & mirror

2M video cable extension $29 (M9972)
3M video cable extension $49 (M9973)
$249 (M997)

TOOL CHEST & ROLLER CABINET

6 Drawer $99 Tool Chest (T650)
- Lockable by key
- Ball bearing slides

5 Drawer $198 Roller Cabinet (T656)
- Lockable by key
- Ball bearing slides

ONLY

PACKAGE PRICE $279
(T650 + T656)

Specifications & Prices are subject to change without notification. All prices include G.S.T. and valid until 28-06-11

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HARE & FORBES MACHINERY HOUSE

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